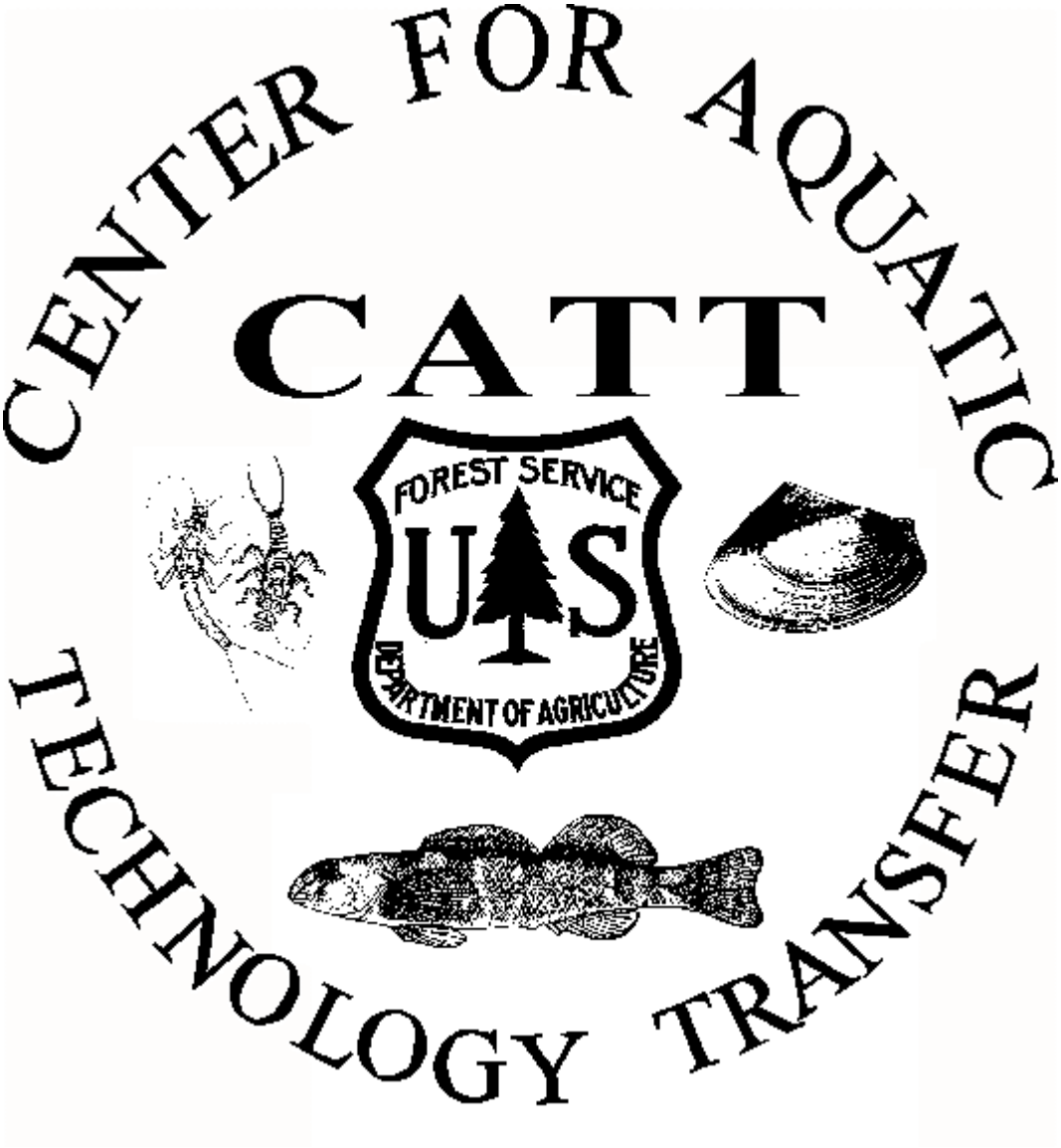
Condition of Fish Populations and Habitat in the St. Mary's River and Selected Tributaries Before and After Limestone Sand Treatment



United States Department of Agriculture Forest Service
Center for Aquatic Technology Transfer
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USDA

Southern Research Station

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Table of Contents

List of Tables

List of Figures

Appendix A

Introduction

The St. Mary's wilderness (SMW) is a 10,090-acre parcel of the George Washington-Jefferson National Forest (GWJNF) established in 1984 by the Virginia Wilderness Bill (Public Law 98-586). Approximately 19 km of stream in the St. Mary's River headwaters flow through the SMW. Acid precipitation and deposition over the last several years have negatively impacted the aquatic biota of the St. Mary's River watershed (Bugas et al. 1999; Kauffman et al. 1999). Forest and resource managers decided to mitigate the effects of acidification by applying limestone sand to St. Mary's River and selected tributaries. In March 1999 140 tons of limestone sand were applied to six streams within the SMW. The acid buffering capabilities of the limestone treatment are expected to last up to five years after application (Downey et al. 2000). Information from pre and post-liming fish surveys are compared in this report to help determine the effects of the limestone treatment on the fish populations and habitat in this watershed.

Study Area

The St. Mary's River is a 3rd order tributary to the South River in the headwaters of the James River drainage. The stream originates at an elevation of 975 m in Augusta County, Virginia (Figure 1). The survey reaches were contained entirely within the SMW boundary and included sections of the St. Mary's River mainstem and 4 of its perennial tributaries (Sugartree Branch, Minebank Creek, Hogback Creek, and Chimney Branch) (Figure 2). The survey reach of each tributary started at the confluence with St. Mary's River.

Methods

Habitat

Habitat surveys were performed during the summers of 1989 and 2002 using a modified version of the two-stage basinwide visual estimation technique (BVET) (Dolloff et. al 1993). During the first stage the survey crew stratified habitat into similar groups based on naturally occurring units including pools, glides, runs, riffles, and cascades (Table 1). Within each habitat unit wetted channel width, maximum depth, average depth, and substrate composition were visually

estimated. Habitat unit lengths were measured using a metric hip chain. Depths were measured with a wading rod marked in 10 cm increments. Substrate was categorized into nine size classes (Table 2). Dominant substrate (covering the greatest surface area in unit) and subdominant substrate (covering the 2nd greatest surface area in unit) were visually estimated in each unit. Large woody debris (LWD) was classified into one of seven (1989) or four (2002) size classes (Tables 3 and 4) and inventoried in each habitat unit. During the second stage wetted channel width was measured using a tape measure in every 5th pool and every 10th riffle (1989) or every 25th pool and every 20th riffle (2002) inventoried. The ratio of estimated width to measured width was used to calibrate all width estimates and stream area and confidence intervals were calculated for all habitat types (Hankin and Reeves 1988).

Additional parameters were added to the habitat survey in 2002. Riffle crest depth (RCD) was estimated by measuring the deepest point in the hydraulic control between riffles and pools. RCD was subtracted from average pool depth during data analysis to calculate an estimate of residual pool depth. Rosgen (1996) channel type was assigned to each habitat unit. Substrate in each unit was identified as embedded if sand, silt, or clay filled the interstitial spaces between larger substrate in over 35% of the surface area of the streambed. Gradient (%) was measured using a clinometer in every 20th riffle. Water temperature (C) was measured and recorded at beginning and end of the survey. Data were analyzed and summarized using MS Excel spreadsheets and SigmaPlot graphics software. Data were recorded on paper forms or using a Husky Hunter (1989) or Husky Fex21 (2002) handheld electronic data loggers.

The GWJNF has outlined in the forest plan desired future conditions (DFC) for instream LWD amounts and stream pool surface area. The LWD DFC is 78 to 186 LWD pieces/km. The pool habitat DFC is pool surface area 30-70% of total stream surface area. DFC's are indicated on figures and tables throughout this report.

Fish

BVET fish surveys performed during the summers of 1989, 1994, 1997, 1999, and 2002 were used to estimate the distribution and abundance of fish in the survey reaches. The dive crew was composed of a diver and data recorder. Typically every 5th pool and every 10th riffle were sampled. The diver entered the downstream end of the habitat unit designated for sampling and

slowly moved upstream identifying species, counting all fish, and noting age classes (age-0 or age+1) for trout species. Throughout this report age-0 trout will be referred to as YOY and trout older than age-0 as adults.

Flagging was used to mark the downstream and upstream end of units designated for a calibration count. Three-pass depletion electrofishing was used to calibrate a subsample of the units sampled by divers. Members of the electrofishing survey crew recorded species, length, and weight of each fish before returning it to the place of capture.

Population densities were calculated by dividing estimated population abundance by estimated stream area. Densities for 1989 and 1994 were calculated using stream areas estimated from the 1989 BVET habitat survey. Densities for 1997, 1999, and 2002 were calculated using stream areas estimated from the 2002 BVET habitat survey.

Results

Habitat

Survey reach lengths varied between the 1989 and 2002 surveys. The 1989 habitat survey of the mainstem started at the confluence with Sugartree Branch and continued upstream for 5.2 km (Table A1). The 2002 mainstem survey started approximately 2.8 km downstream from the Sugartree Branch confluence (at wilderness boundary adjacent to trailhead parking area) and progressed upstream 7.7 km (Table A2). Throughout this report the reach starting at the Sugartree Branch confluence will be referred to as the upper mainstem (ms) reach and the reach starting near the wilderness boundary as the entire ms reach. Reach lengths of the tributaries also varied between the two surveys. All 2002 reach lengths were longer than in 1989 (Appendix A). When reaches were adjusted to similar lengths total stream surface areas were approximately equal. Total stream surface area for the upper ms reach (starting from the Sugartree Branch confluence) for 1989 was 22013.6 m^2 ± 891.9 m^2 and 2002 was 22266.4 m^2 ± 1218.3 m^2 (Table A1 and A2). Reach lengths for Hogback Creek were approximately equal between years and the total stream surface areas were 1909.0 m^2 ± 67.9 m^2 for 1989 and 1990.7 m^2 ± 351.7 m^2 for 2002 (Table A1 and A2).

The seven LWD categories (Table 3) from the 1989 survey were converted to four size categories (Table 4) to compare with the 2002 survey. The amounts of LWD per kilometer in St. Mary's River upper ms reach were higher during the 2002 survey. 37 total pieces/km were counted in 1989 and 49 total pieces/km in 2002 (Table A3). Size category compositions were similar between years with size 1 making up the majority of LWD pieces followed by size 3 for both surveys. LWD pieces/km amounts were higher for all the tributaries during the 2002 survey (Tables A4, A5 and A6). Size 1 made up the majority of LWD pieces followed by size 3 in all the tributaries during both surveys. None of the LWD minimum DFC's were met in any of the reaches during the 1989 survey except in Hogback Creek. During the 2002 survey minimum LWD DFC's were exceeded in all the survey reaches except St. Mary's River upper ms (Figures A5, A11, A17, A23 and A36). All habitat results are summarized in Appendix A.

Fish

Composition

A total of eight species were observed in the St. Mary's River in 1989, 1994, 1997, 1999,and 2002 (Table B1). Brook trout, blacknose dace, and fantail darter were the only species observed during all five surveys (Table B1). Rainbow trout was only observed in 1989. The highest number of species (seven) was observed during the 2002 survey. The lowest number of species (three) was observed during the 1997 survey. St. Mary's River tributaries were surveyed in 1997, 1999, and 2002. Brook trout were observed in all four tributaries during all three surveys (Table B9). Mottled sculpin (the only fish other than brook trout found in any of the tributaries) were observed in Sugartree Branch only and found during all three surveys (Table B10).

Densities

Density estimates were calculated for brook trout in St. Mary's River upper ms reach for all sampling periods and the entire ms reach for 1997, 1999, and 2002 (Table B2). Brook trout density estimates in the upper ms reach ranged from 5 (±5) fish/100 m^2 in 1989 to 23 (±8) fish/100 m^2 in 2002. Brook trout density estimates in the entire ms reach ranged from 12 (±6) fish/100 m2 in 1999 to 20 (±7) fish/100 m2 in 2002. Blacknose dace density estimates were calculated in St. Mary's River upper ms reach for 1989, 1994, and 2002 and the entire ms reach for 1997, 1999, and 2002 (Table B3). Blacknose dace density estimates in the upper ms reach ranged from 0.4 (±0.7) fish/100 m^2 in 1989 to 5.4 (±1.7) fish/100 m^2 in 2002.

Data for all tributary survey reaches were combined for analysis. Brook trout density estimates for 1994, 1997, 1999, and 2002 were calculated for the total area of all tributaries (Table B6) and using population estimates of fish in pools only due to lack of data from riffles. Brook trout densities in all tributaries ranged from 5 fish/100 m^2 in 1994, 1997, and 1999 to 10 (±7) fish/100 m^2 in 2002 (Table B6).

Distribution

Distribution of fish species in the St. Mary's watershed was described using both diver count and electrofishing information. Species distribution was defined as the distance from the start of the survey reach to the upstream most point where the species was encountered during sampling in 1989,1997, 1999, and 2002 (Table B9). Of the eight species observed, five (brook trout, rainbow trout, fantail darter, central stoneroller, and torrent sucker) were found furthest upstream in 1989. Roseyside dace were found furthest upstream in 1999 and blacknose dace and mottled sculpin were found furthest upstream in 2002. During the 2002 survey only brook trout and blacknose dace were found above a series of waterfalls approximately four km upstream of the wilderness boundary. During all other surveys brook trout were the only species observed above the falls. Brook trout were observed furthest upstream in 2002 in all four tributaries (Table B10). Mottled sculpin in Sugartree branch were observed furthest upstream in 2002 (Table B11).

Conclusion

BVET habitat survey stream reach lengths and survey beginning and ending points varied between the 1989 surveys and the 2002 surveys. When survey lengths of the same reach were approximately equal stream surface areas were also about equal. By using the same methods in 1989 and 2002 we were able to use stream surface areas from both surveys to calculate fish densities (fish/100 m^2) and compare them between years.

The increase in amount of LWD pieces/km from 1989 to 2002 could be linked to several factors including disease and natural processes. The hemlock woolly adelgid and gypsy moth are known to have infested the area including the SMW since the1989 habitat survey (Liebhold 1998, USDA Forest Service 2002). The long term drought in effect in Virginia and this area could also be a factor in the increase of LWD input.

Recording hip-chain distances of sampled units and landmarks such as confluences during the habitat and fish surveys allowed us to compare fish distributions between years. The series of waterfalls on the mainstem of St. Mary's River approximately four km upstream of the wilderness boundary probably limited upstream distribution of all species besides brook trout and blacknose dace. Habitat and life history requirements probably limited species other than brook trout from moving into Mine Bank Creek from St. Mary's River as there were no physical barriers near the confluence to upstream distribution. Mottled sculpin occupied a short section of lower Sugartree Branch and brook trout occupied a greater length of the stream but no other species were present during sampling despite the lack of a physical barrier to upstream distribution at the confluence.

Without consecutive years of data it was difficult to come to any conclusions about differences in fish densities or determine trends in pre- and post-liming populations. Brook trout population sizes are known to be highly variable due to several natural conditions (Elwood and Waters 1969, Hunt 1974, Reice et al. 1990, Marschall and Crowder 1996) and the fluctuations in densities here may reflect several factors not just the effects of the liming. Despite the lack of obvious population trends the highest observed brook trout and blacknose dace densities in St. Mary's River occurred after the liming in 2002.

The upstream most distribution of blacknose dace also occurred after the treatment. Although upstream most distributions of fish in all the tributaries were observed during 2002, survey lengths for all tributary reaches extended further upstream in 2002 than in previous years. The true upstream most distribution of fish may not be known in the tributaries prior to the 2002 survey.

The Virginia Department of Game and Inland Fisheries has monitored fish populations of the St. Mary's River within the SMW from 1976 to 2002. James Madison University continues to monitor water quality prior to the liming treatment to present. These data along information collected by the Forest Service provide good insight to the condition of fish population and overall stream health. To further monitor species populations and distributions post-liming treatment, additional surveys are needed.

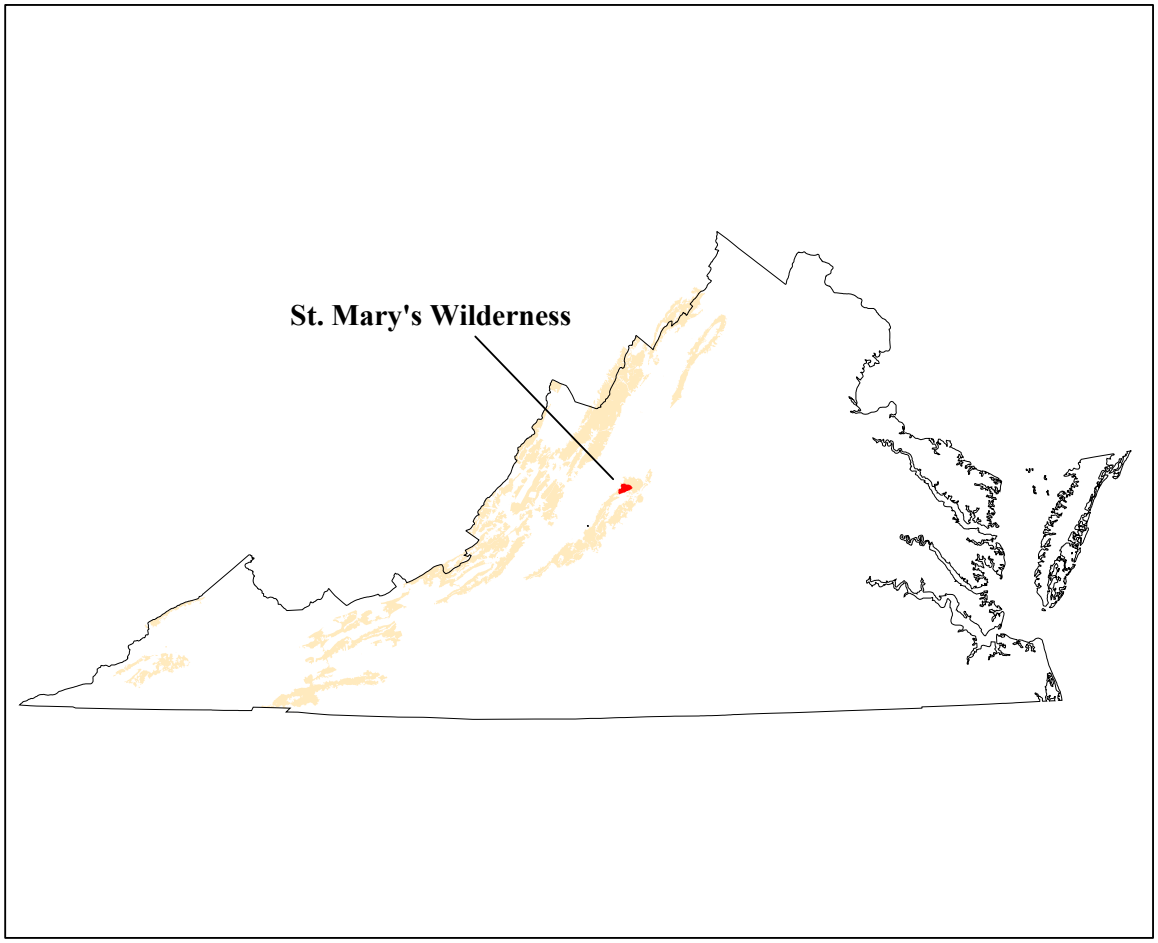

Figure 1. Map showing location of St. Mary's Wilderness in Virginia.

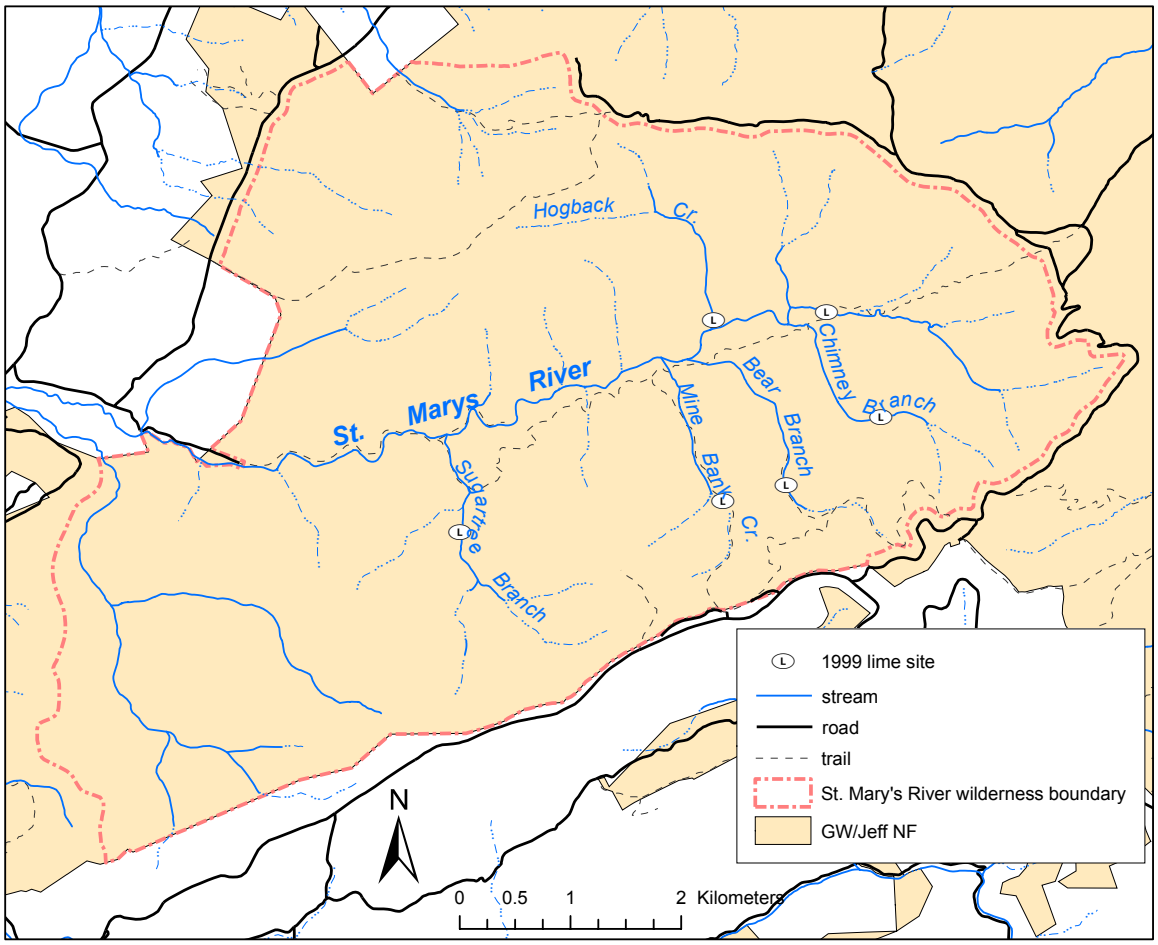

Figure 2. Map showing locations of surveyed streams and liming sites.

Table 1. Description of habitat types used during BVET habitat surveys.

habitat type	channel bottom profile	gradient (%)	water surface	water velocity
pool	concave	0	smooth	low
glide	flat	0	smooth	low
run	flat	>0	turbulent	high
riffle	convex	>0	turbulent	high
cascade	convex, exposed substrate	>12	turbulent	very high

Table 2. Size classes used to categorize substrate during BVET habitat surveys. Diameter was estimated for the intermediate axis.

Size Class	Name	Size (mm)	Description
1	Organic	--	Dead organic matter, leaves, detritus, etc.
2	Clay	< .00024	Sticky
3	Silt	.00024-.0039	Slippery
4	Sand	.0039-2	Gritty
5	Small Gravel	2-10	Sand to thumbnail
6	Large Gravel	11-100	Thumbnail to fist
7	Cobble	101-300	Fist to head
8	Boulder	>300	Larger than head
9	Bedrock	--	Solid parent material

Table 3. Size classes used to categorize large woody debris (LWD) during BVET habitat surveys on the St. Mary's River and its tributaries in 1989. Woody debris < 1.0 m in length or < 10 cm in diameter were omitted.

Size Class	Length (m)	Diameter (cm)
1	< 5	5 – 10
2	< 5	10 – 50
3	< 5	> 50
4	> 5	5 – 10
5	> 5	10 – 50
6	> 5	> 50
7	rootwad	rootwad

Table 4. Size classes used to categorize LWD during BVET habitat surveys on the St. Mary's River and its tributaries in 2002. Woody debris < 1.0 m in length or < 10 cm in diameter were omitted.

Size Class	Length (m)	Diameter (cm)
1	< 5	10-55
2	< 5	> 55
3	> 5	10-55
4	> 5	> 55

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Appendix A: Habitat Survey Summaries

Table A1. Summary of habitat characteristics of the St. Mary's River and selected tributaries surveyed using BVET habitat surveys, 1989.

stream/reach	date surveyed	distance surveyed (km)	pool area (m^2)	riffle area (m^2)	total stream surface area (m^2)
St. Mary's River/upper ms	07/09/89	5.2	14654 ± 694	7360 ± 586	220134 ± 892
Mine Bank Cr.	07/11/89	0.5	346 ± 13	763 ± 13	1109 ± 21
Hogback Cr.	07/09/89	0.9	782 ± 49	1127 ± 34	1909 ± 68
Chimney Br.	07/11/89	0.5	358 ± 13	606 ± 40	397 ± 167

Table A2. Summary of habitat characteristics of the St. Mary's River and selected tributaries surveyed using BVET habitat surveys, 2002.

stream/reach	date surveyed	distance surveyed (km)	pool area (m^2)	riffle area (m^2)	total stream surface area (m^2)
St. Mary's River/entire ms	07/29/02	7.7	17979 ± 674	18495 ± 3683	36474 ± 3571
St. Mary's River/upper ms	07/29/02	4.9	12700 ± 484	9566 ± 1102	22264 ± 1218
Sugartree Br.	07/29/02	1.6	1493 ± 89	1632 ± 207	3125 ± 222
Mine Bank Cr.	07/31/02	1.8	1142 ± 128	2230 ± 220	3372 ± 249
Hogback Cr.	07/30/02	1.0	765 ± 86	1226 ± 451	1991 ± 352
Chimney Br.	07/31/02	1.5	1135 ± 284	1031 ± 1416	2166 ± 1444

Table A3. Summary of habitat characteristics for St. Mary's River upper mainstem, 1989, 2002.

Stream/reach:	**St. Mary's River/upper ms**	
NF District:	Pedlar	
USGS Quadrangle:	Big Levels	
	1989	**2002**
Survey Date:	07/09/89	07/29/02
Downstream Starting Point:	Confluence w/ Sugartree Branch	Confluence w/ Sugartree Branch
Total Distance Surveyed (km):	5.2	4.9

	Pools		**Riffles**	
	1989	**2002**	**1989**	**2002**
Percent of Total Stream Area:	67	57	33	43
Total Area (m^2):	14654 ± 694	12700 ± 484	7360 ± 586	9566 ± 1102
Correction Factor Applied:	1.01	0.91	1.02	0.97
Number of Paired Samples:	73	8	25	10
Total Count:	408	218	243	195
Number per km:	79	44	47	40
Mean Area (m^2):	36	58	30	49
Mean Maximum Depth (cm):	51	53	13	22
Mean Average Depth (cm):	34	29	15	13
Mean Residual Depth (cm):	--	17	--	--
Percent Surveyed as Glides:	33	8	--	--
Percent Surveyed as Runs:	--	--	--	8
Percent Surveyed as Cascades:	--	--	17	0
Percent with Substrate > 35% Embedded:	--	7	--	--

	Pieces per km	
Large Woody Debris Size	**1989**	**2002**
< 5 m long, 10 cm – 55 cm diameter:	32	44
< 5 m long, > 55 cm diameter:	1	0
> 5 m long, 10 cm – 55 cm diameter:	3	5
> 5 m long, > 55 cm diameter:	0	0
Total:	37	49

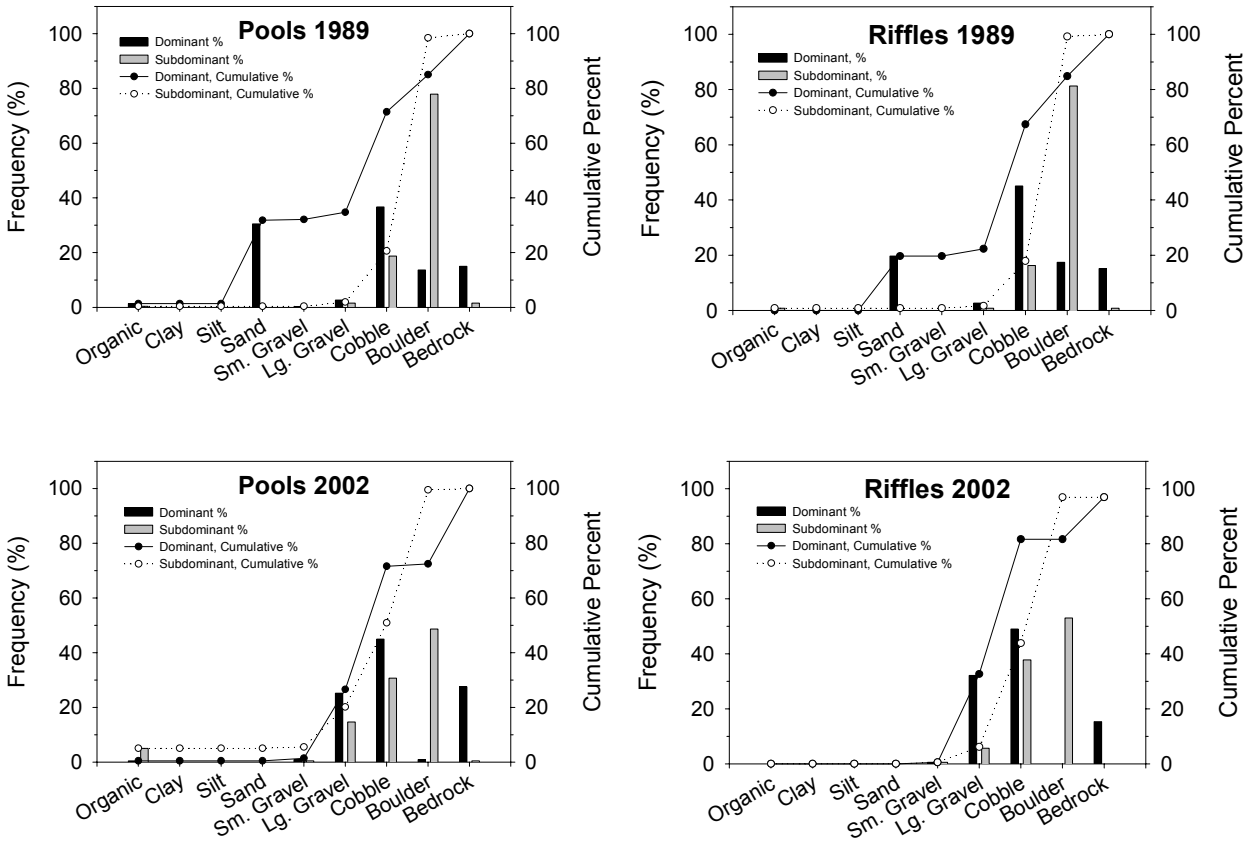

Figure A1. Frequency (percent) and cumulative percent of dominant and subdominant substrate occurrence in pools and riffles in St. Mary's River upper ms, 1989 and 2002.

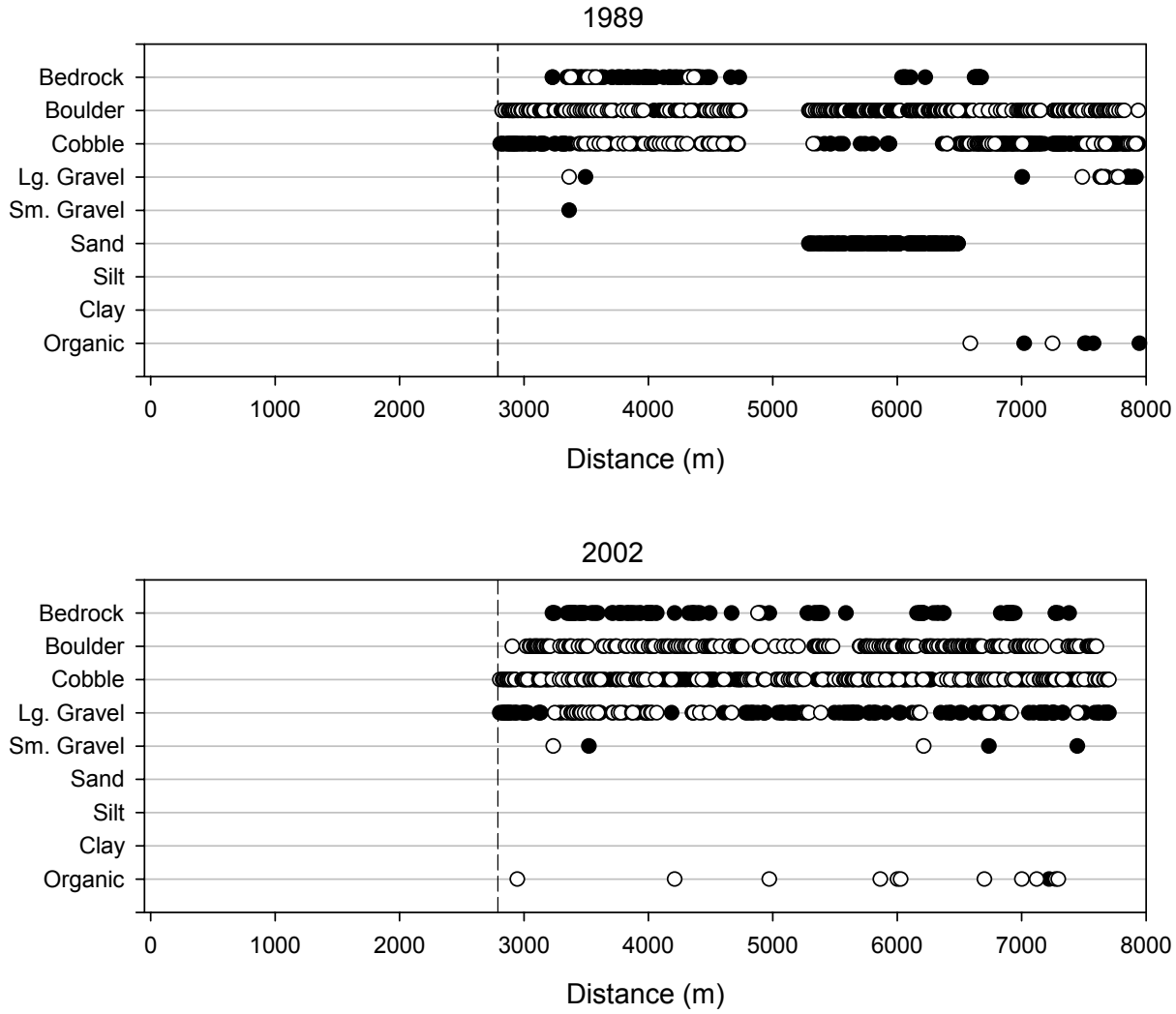

Figure A2. Distribution of substrate types (Table 2) in St. Mary's River upper ms, 1989 and 2002. Closed circles are dominant substrates, open circles are subdominant substrates. Distance is meters upstream of wilderness boundary. Vertical dashed line indicates confluence with Sugartree Branch.

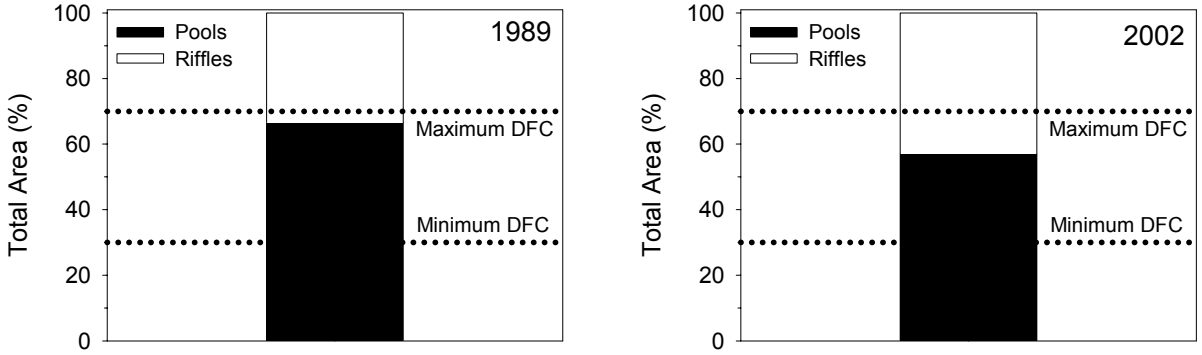

Figure A3. Estimated area of St. Mary's River upper ms reach pools and riffles as calculated using BVET techniques, 1989 and 2002. The GWJNF DFC is between 30 and 70 percent of total stream area in pools.

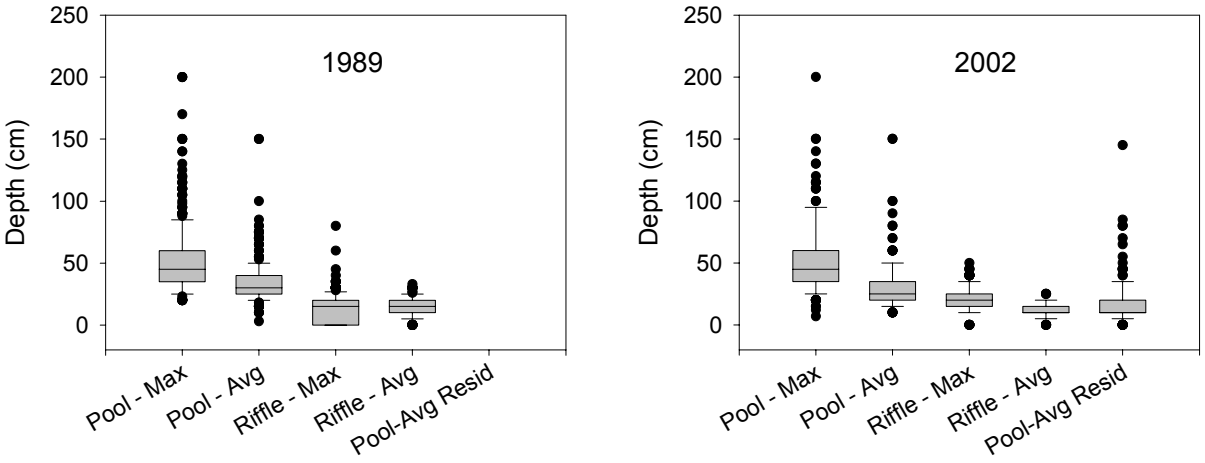

Figure A4. Maximum and average depths for pools and riffles and residual depths in St. Mary's River upper ms, 1989 and 2002. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of the box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data. Residual depths were not calculated for 1989.

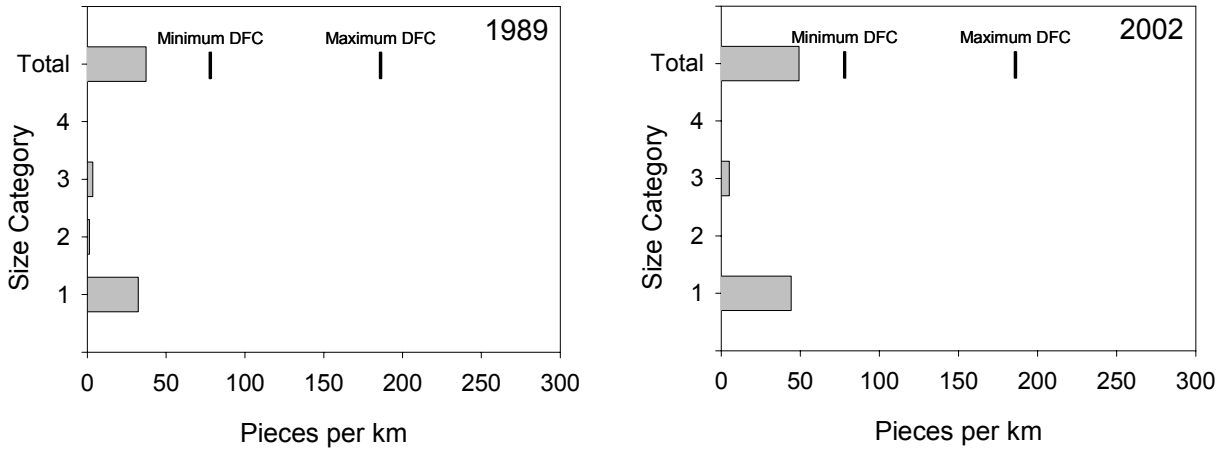

Figure A5. LWD per kilometer in St. Mary's River upper ms reach, 1989 and 2002. The GWJNF DFC for total LWD is between 78 and 186 pieces per km.

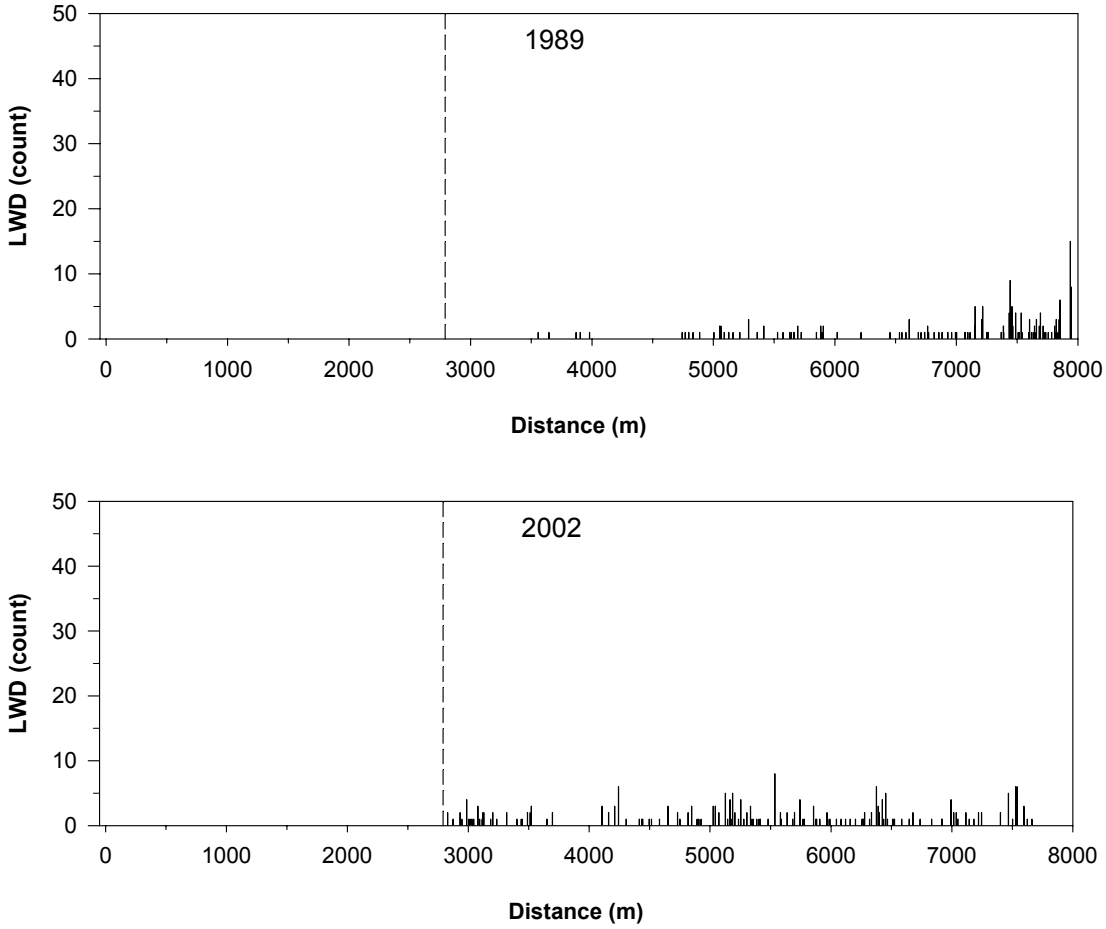

Figure A6. Distribution and abundance of LWD in St. Mary's River upper ms reach, 1989 and 2002. Vertical bars indicate total count of LWD. Open circles represent the amount of the total that was >5m in length and >55cm in diameter (size 4). Distance is meters upstream of wilderness boundary. Vertical dashed line indicates the confluence with Sugartree branch.

Table A4. Summary of habitat characteristics for Mine Bank Creek, 1989 and 2002.

Stream/reach:	**Mine Bank Creek**	
NF District:	Pedlar	
USGS Quadrangle:	Big Levels	
	1989	**2002**
Survey Date:	05/29/89	07/31/02
Downstream Starting Point:	confluence w/ St. Mary's River	confluence w/ St. Mary's River
Total Distance Surveyed (km):	0.5	1.8

	Pools		**Riffles**	
	1989	**2002**	**1989**	**2002**
Percent of Total Stream Area:	31	34	69	66
Total Area (m^2):	346 ± 13	1142 ± 128	763 ± 13	2230 ± 220
Correction Factor Applied:	0.98	1.03	0.99	1.06
Number of Paired Samples:	8	13	3	13
Total Count:	40	125	36	103
Number per km:	78	69	70	57
Mean Area (m^2):	9	9	21	22
Mean Maximum Depth (cm):	33	29	15	12
Mean Average Depth (cm):	23	18	9	5
Mean Residual Depth (cm):	--	13	--	--
Percent Surveyed as Glides:	0	26	--	--
Percent Surveyed as Runs:	--	--	0	0
Percent Surveyed as Cascades:	--	--	3	14
Percent with Substrate > 35% Embedded:	--	6	--	--

	Pieces per km	
Large Woody Debris Size	**1989**	**2002**
< 5 m long, 10 cm – 55 cm diameter:	52	202
< 5 m long, > 55 cm diameter:	2	3
> 5 m long, 10 cm – 55 cm diameter:	10	49
> 5 m long, > 55 cm diameter:	2	1
Total:	66	255

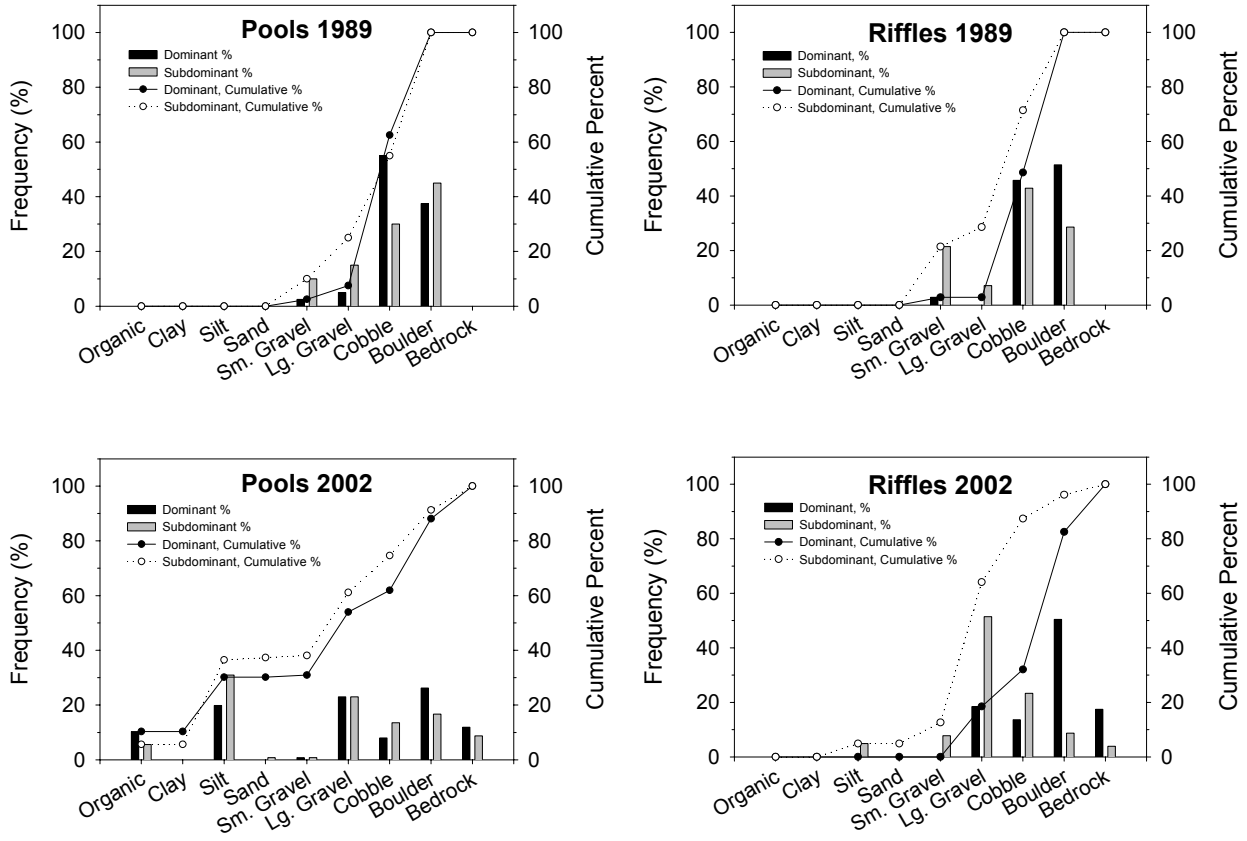

Figure A7. Frequency (percent) and cumulative percent of dominant and subdominant substrate occurrence in pools and riffles in Mine Bank Creek, 1989 and 2002.

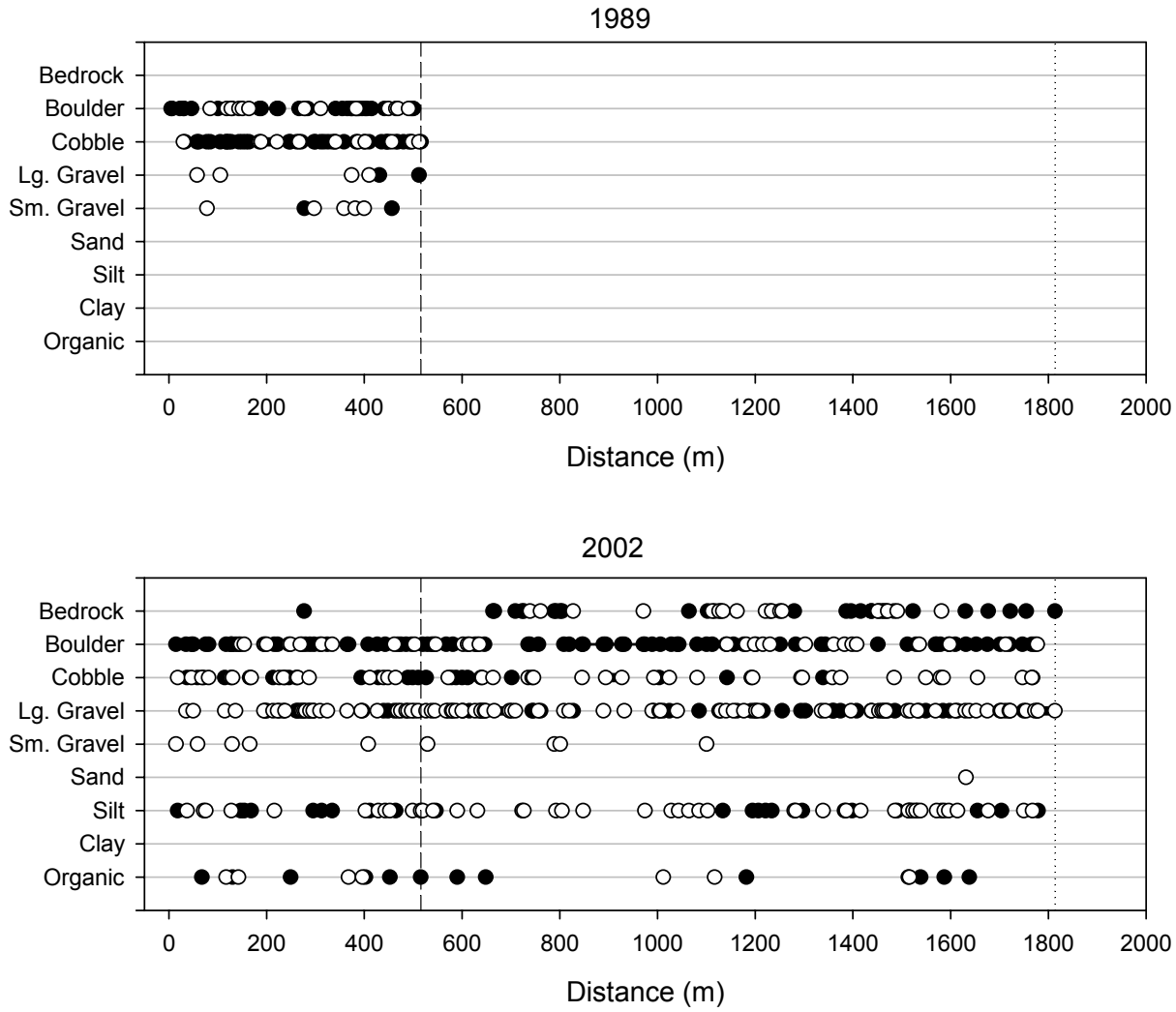

Figure A8. Distribution of substrate types (Table 2) in Mine Bank Creek, 1989 and 2002.. Closed circles are dominant substrates, open circles are subdominant substrates. Distance is meters upstream of confluence with St. Mary's River. Vertical dashed line indicates end of 1989 BVET habitat survey. Vertical dotted line indicates end of 2002 BVET habitat survey.

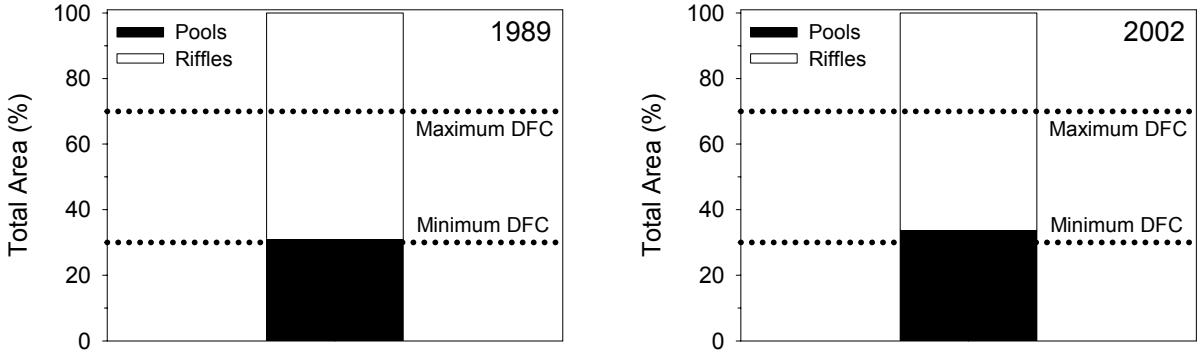

Figure A9. Estimated area of Mine Bank Creek pools and riffles as calculated using BVET techniques, 1989 and 2002. The GWJNF DFC is between 30 and 70 percent of total stream area in pools.

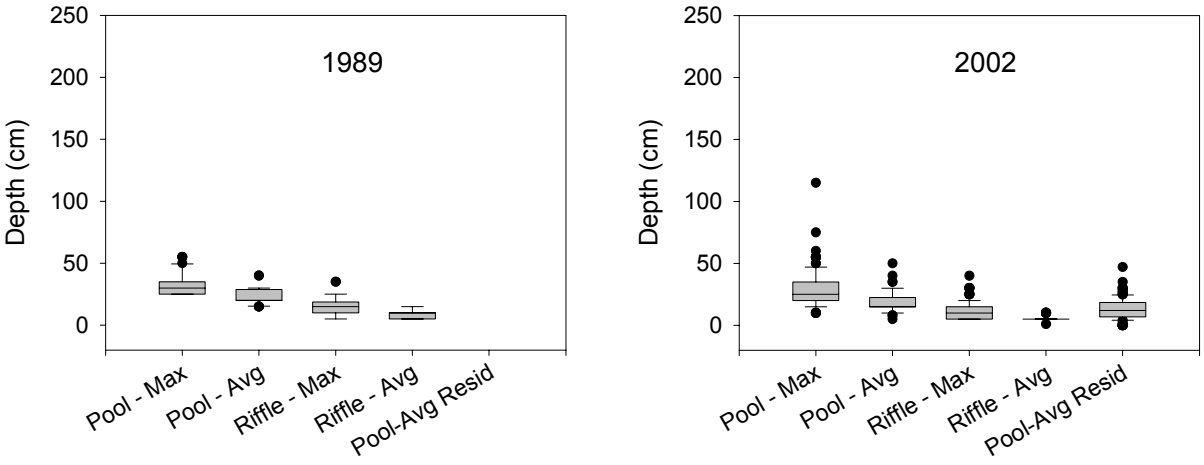

Figure A10. Maximum and average depths for pools and riffles in Mine Bank creek, 1989 and 2002. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of the box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data. Residual depths were not calculated for 1989.

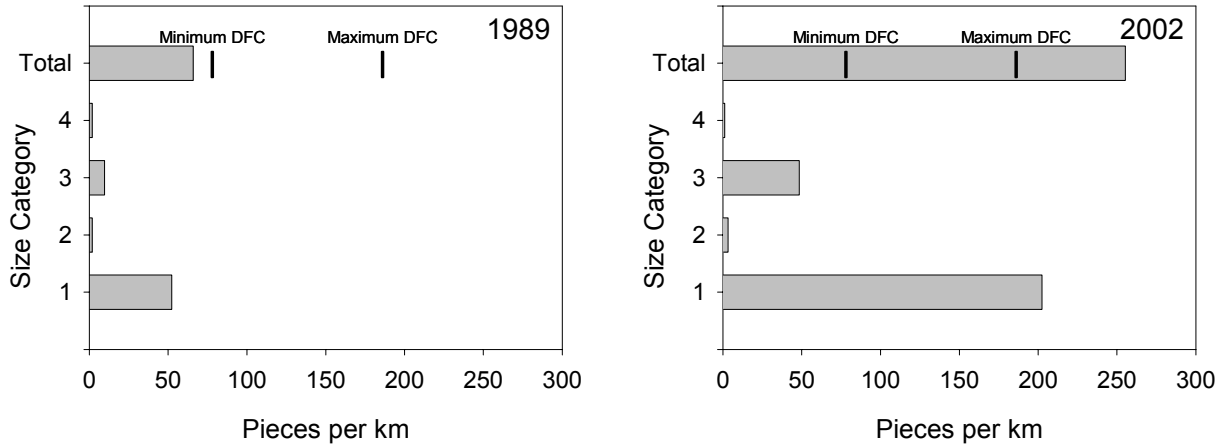

Figure A11. LWD per kilometer in Mine Bank creek, 1989 and 2002. The GWJNF DFC for total LWD is between 78 and 186 pieces per km.

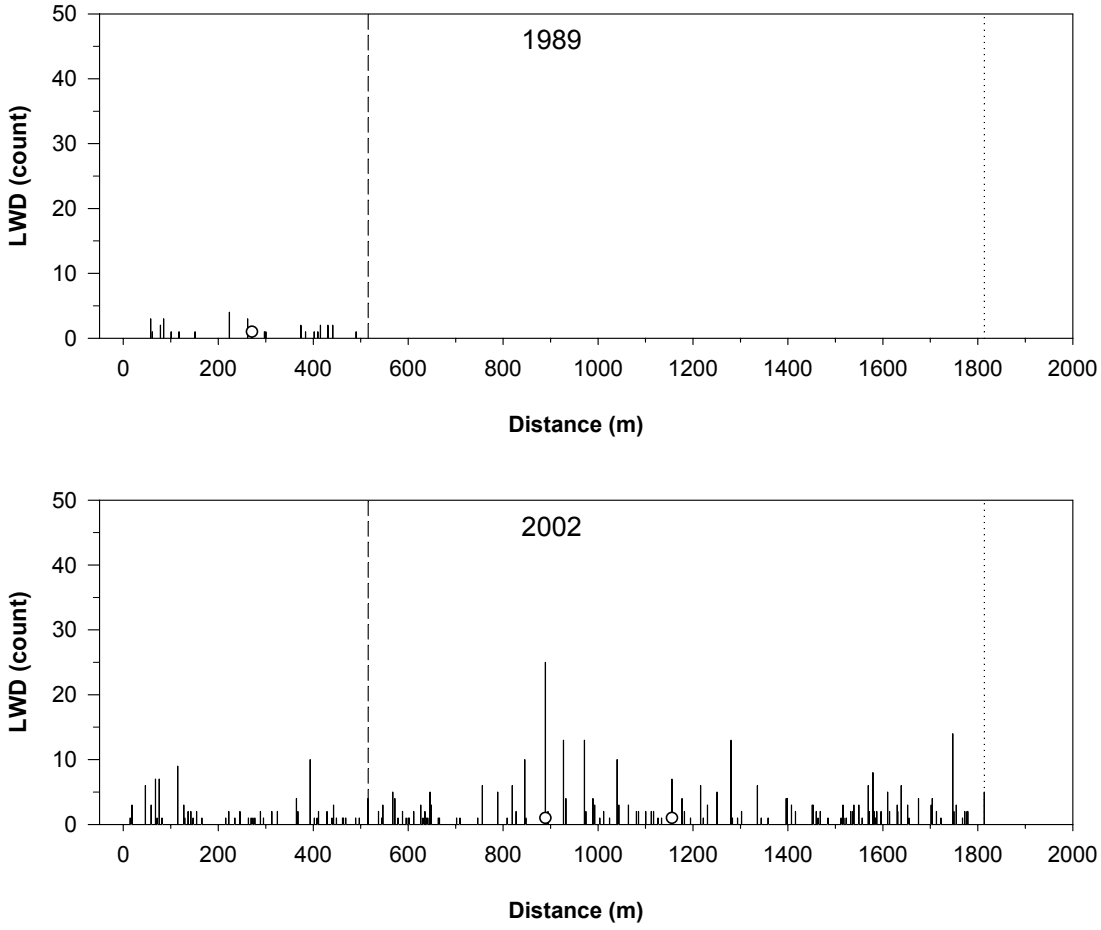

Figure A12. Distribution and abundance of LWD in Mine Bank creek, 1989 and 2002. Vertical bars indicate total count of LWD. Open circles represent the amount of the total that was >5m in length and >55cm in diameter (size 4). Distance is meters upstream of confluence with St. Mary's River. Vertical dashed line indicates end of 1989 BVET habitat survey. Vertical dotted line indicates end of 2002 BVET habitat survey.

Table A5. Summary of habitat characteristics for Hogback Creek, 1989 and 2002.

Stream/reach:	**Hogback Creek**	
NF District:	Pedlar	
USGS Quadrangle:	Big Levels	
	1989	**2002**
Survey Date:	07/09/89	07/30/02
Downstream Starting Point:	confluence w/ St. Mary's River	confluence w/ St. Mary's River
Total Distance Surveyed (km):	0.9	1.0

	Pools		**Riffles**	
	1989	**2002**	**1989**	**2002**
Percent of Total Stream Area:	41	38	59	62
Total Area (m^2):	782 ± 49	765 ± 86	1127 ± 34	1226 ± 451
Correction Factor Applied:	0.96	0.98	0.93	1.30
Number of Paired Samples:	15	4	9	4
Total Count:	72	63	76	54
Number per km:	82	63	87	54
Mean Area (m^2):	11	12	15	23
Mean Maximum Depth (cm):	42	39	19	16
Mean Average Depth (cm):	28	25	10	8
Mean Residual Depth (cm):	--	21	--	--
Percent Surveyed as Glides:	8	5	--	--
Percent Surveyed as Runs:	--	--	0	6
Percent Surveyed as Cascades:	22	--	17	6
Percent with Substrate > 35% Embedded:	--	6	--	--

	Pieces per km	
Large Woody Debris Size	**1989**	**2002**
< 5 m long, 10 cm – 55 cm diameter:	65	147
< 5 m long, > 55 cm diameter:	7	0
> 5 m long, 10 cm – 55 cm diameter:	14	42
> 5 m long, > 55 cm diameter:	1	4
Total:	87	193

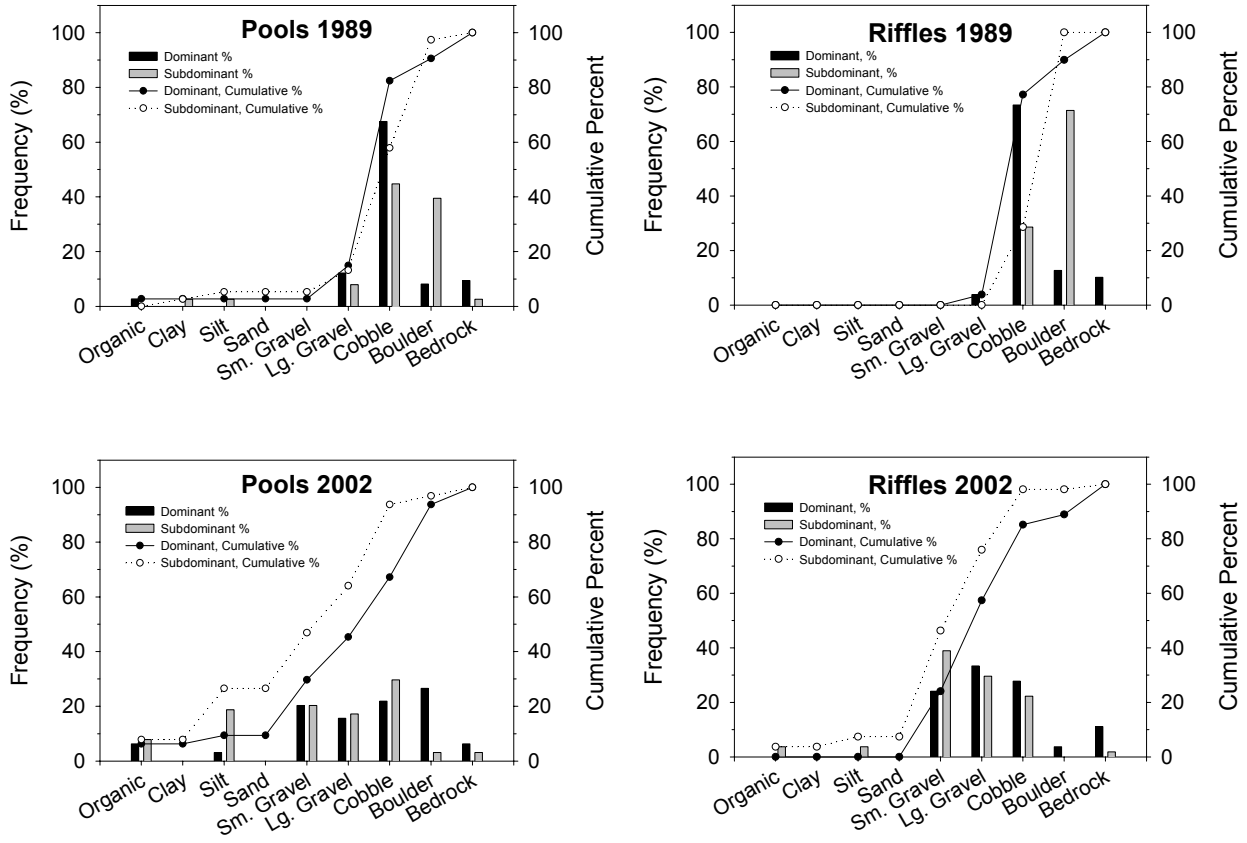

Figure A13. Frequency (percent) and cumulative percent of dominant and subdominant substrate occurrence in pools and riffles in Hogback Creek, 1989 and 2002.

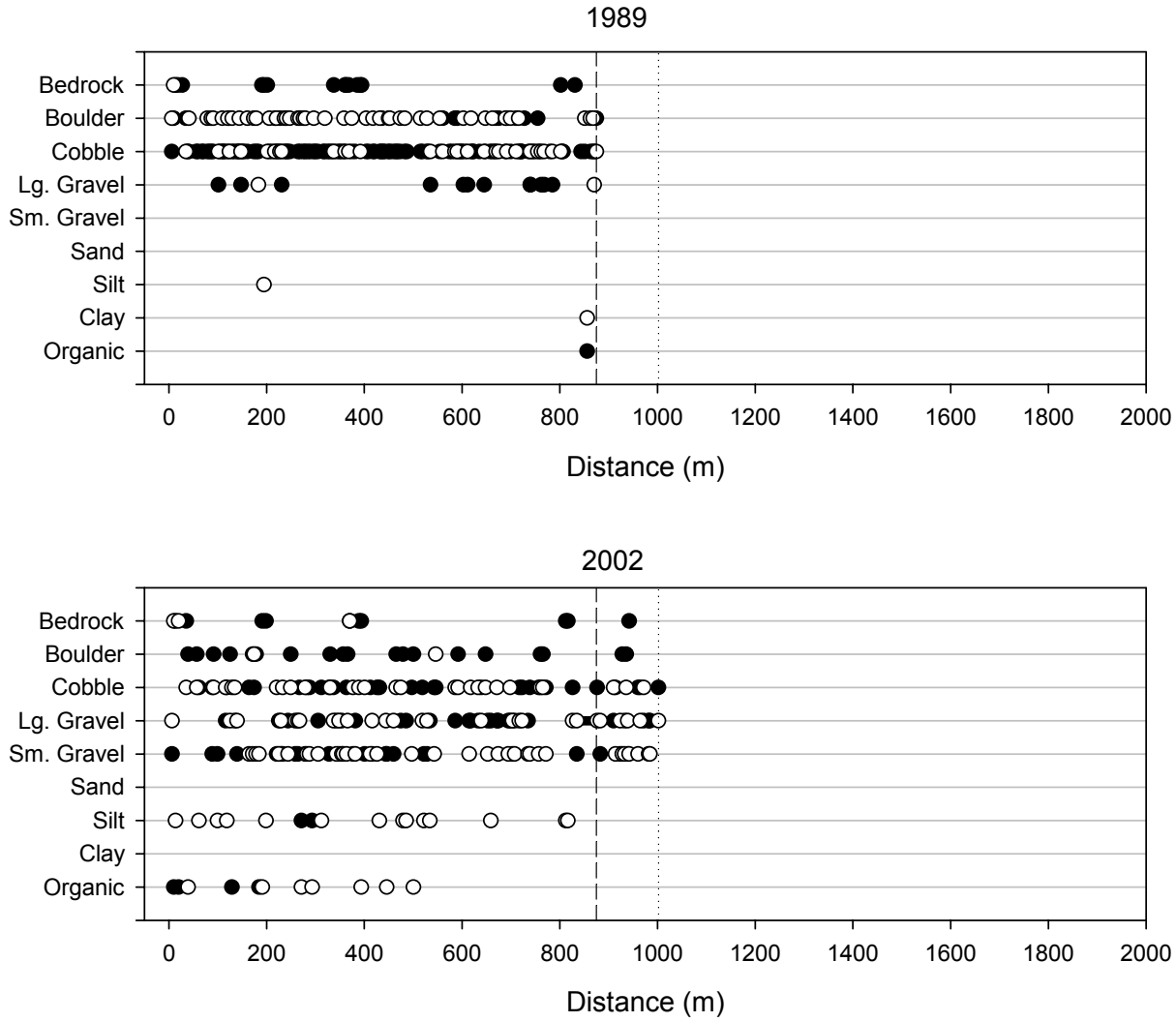

Figure A14. Distribution of substrate types (Table 2) in Hogback Creek, 1989 and 2002. Closed circles are dominant substrates, open circles are subdominant substrates. Distance is meters upstream of confluence with St. Mary's River. Vertical dashed line indicates end of 1989 BVET habitat survey. Vertical dotted line indicates end of 2002 BVET habitat survey.

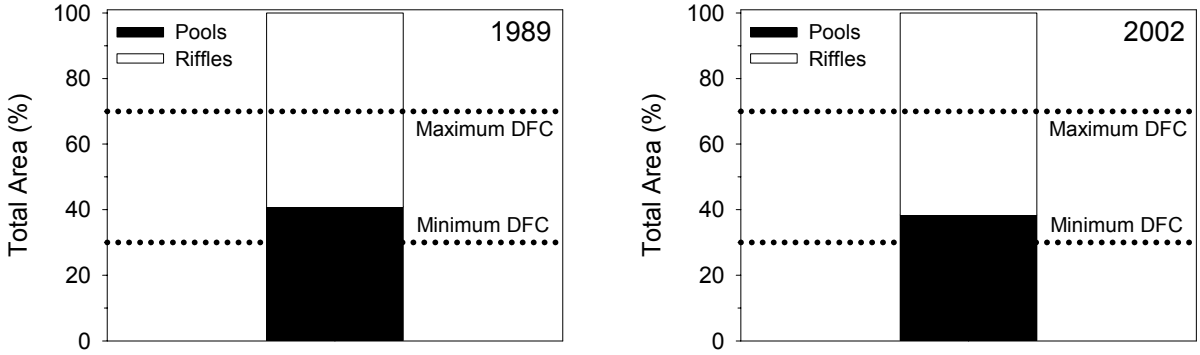

Figure A15. Estimated area of Hogback Creek pools and riffles as calculated using BVET techniques, 1989 and 2002. The GWJNF DFC is between 30 and 70 percent of total stream area in pools.

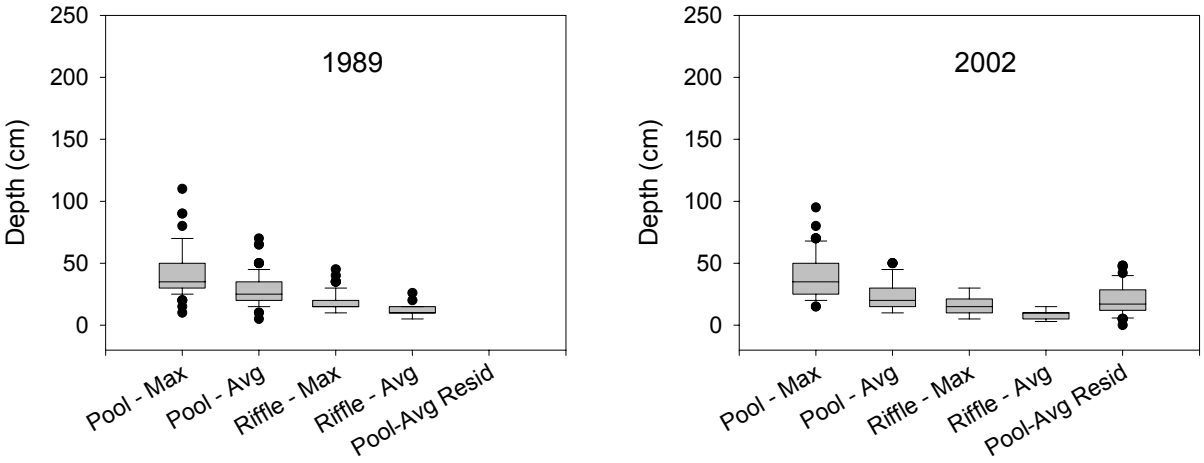

Figure A16. Maximum and average depths for pools and riffles in Hogback Creek, 1989 and 2002. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of the box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data. Residual depths were not calculated for 1989.

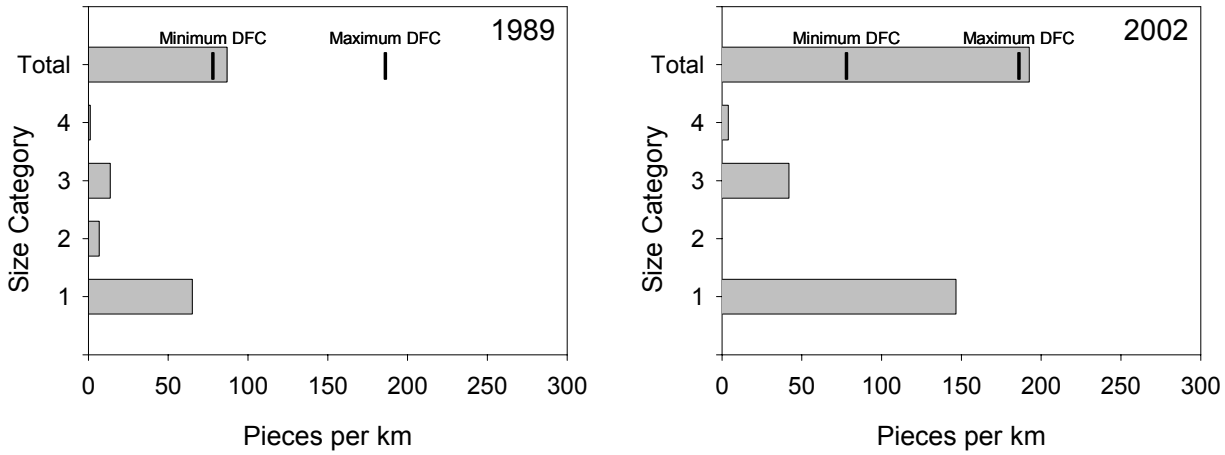

Figure A17. LWD per kilometer in Hogback Creek, 1989 and 2002. The GWJNF DFC for total LWD is between 78 and 186 pieces per km.

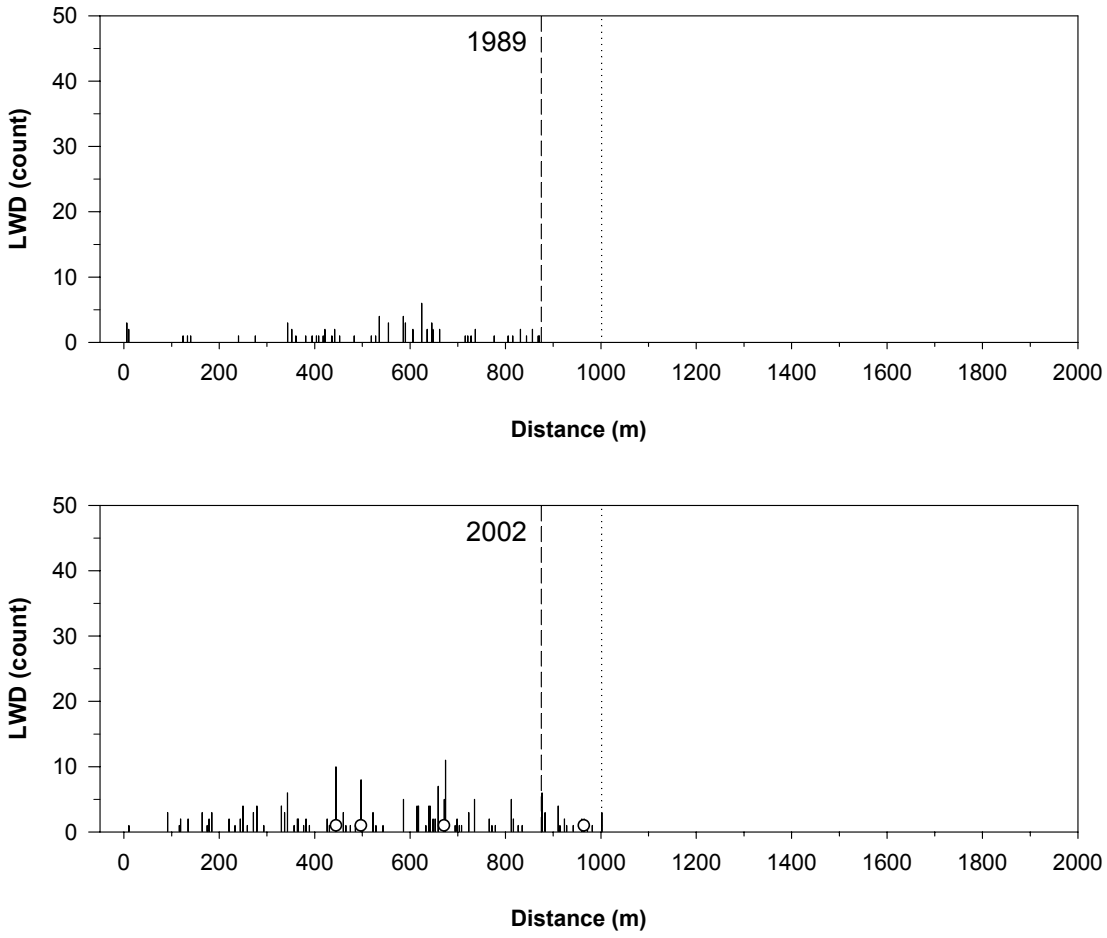

Figure A18. Distribution and abundance of LWD in Hogback Creek, 1989 and 2002. Vertical bars indicate total count of LWD. Open circles represent the amount of the total that was >5m in length and >55cm in diameter (size 4). Distance is meters upstream of confluence with St. Mary's River. Vertical dashed line indicates end of 1989 BVET habitat survey. Vertical dotted line indicates end of 2002 BVET habitat survey.

Table A6. Summary of habitat characteristics for Chimney Branch, 1989 and 2002.

Stream/reach:	**Chimney Branch**	
NF District:	Pedlar	
USGS Quadrangle:	Big Levels	
	1989	**2002**
Survey Date:	07/11/89	07/31/02
Downstream Starting Point:	confluence w/ St. Mary's River	confluence w/ St. Mary's River
Total Distance Surveyed (km):	0.5	1.5

	Pools		**Riffles**	
	1989	**2002**	**1989**	**2002**
Percent of Total Stream Area:	37	52	63	48
Total Area (m^2):	358 ± 13	1135 ± 284	606 ± 39	1031 ± 1416
Correction Factor Applied:	0.91	1.06	0.72	0.85
Number of Paired Samples:	7	4	2	4
Total Count:	41	112	37	83
Number per km:	77	74	70	55
Mean Area (m^2):	10	10	23	12
Mean Maximum Depth (cm):	32	26	15	13
Mean Average Depth (cm):	22	16	8	6
Mean Residual Depth (cm):	--	9	--	--
Percent Surveyed as Glides:	2	33	--	--
Percent Surveyed as Runs:	--	--	0	2
Percent Surveyed as Cascades:	--	--	8	1
Percent with Substrate > 35% Embedded:	--	11	--	--

	Pieces per km	
Large Woody Debris Size	**1989**	**2002**
< 5 m long, 10 cm – 55 cm diameter:	32	137
< 5 m long, > 55 cm diameter:	0	1
> 5 m long, 10 cm – 55 cm diameter:	11	44
> 5 m long, > 55 cm diameter:	0	3
Total:	43	184

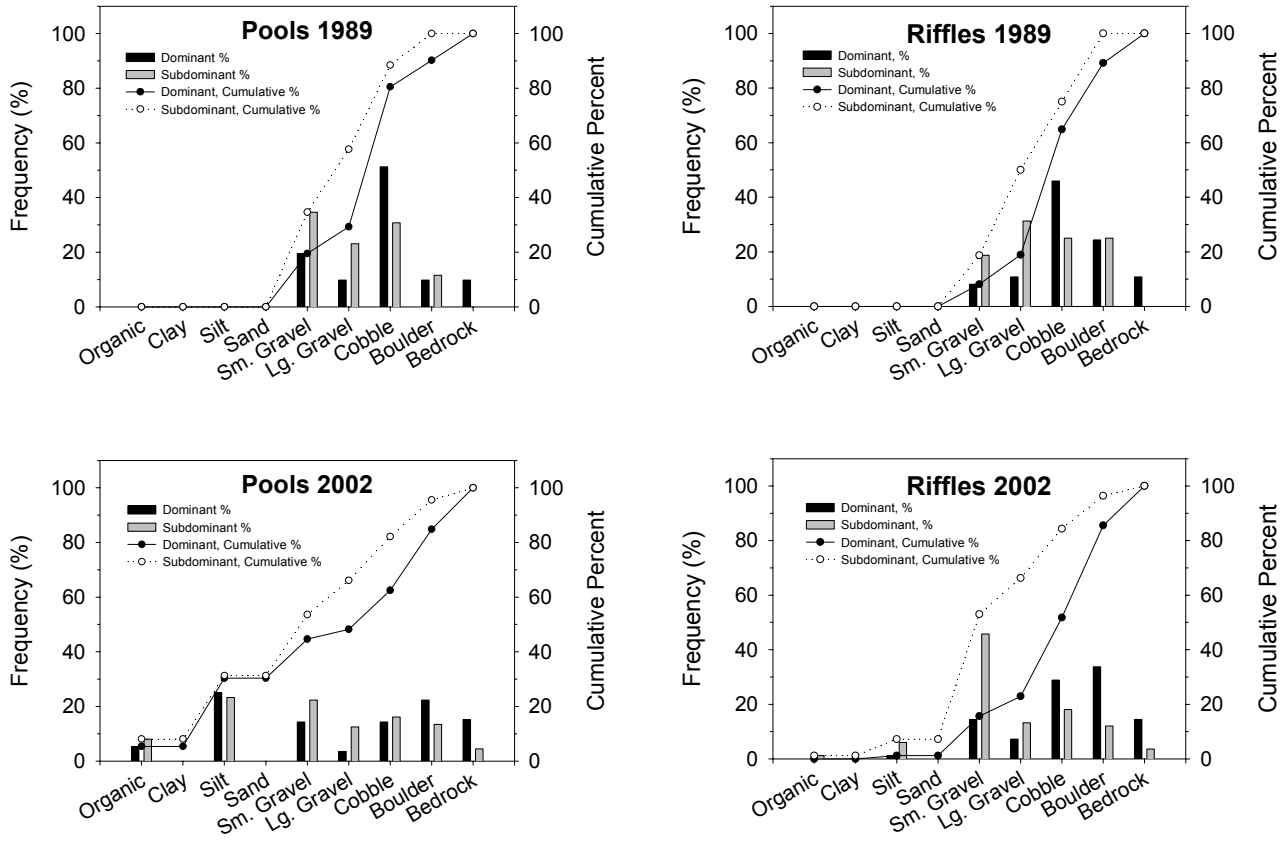

Figure A19. Frequency (percent) and cumulative percent of dominant and subdominant substrate occurrence in pools and riffles in Chimney Branch, 1989 and 2002.

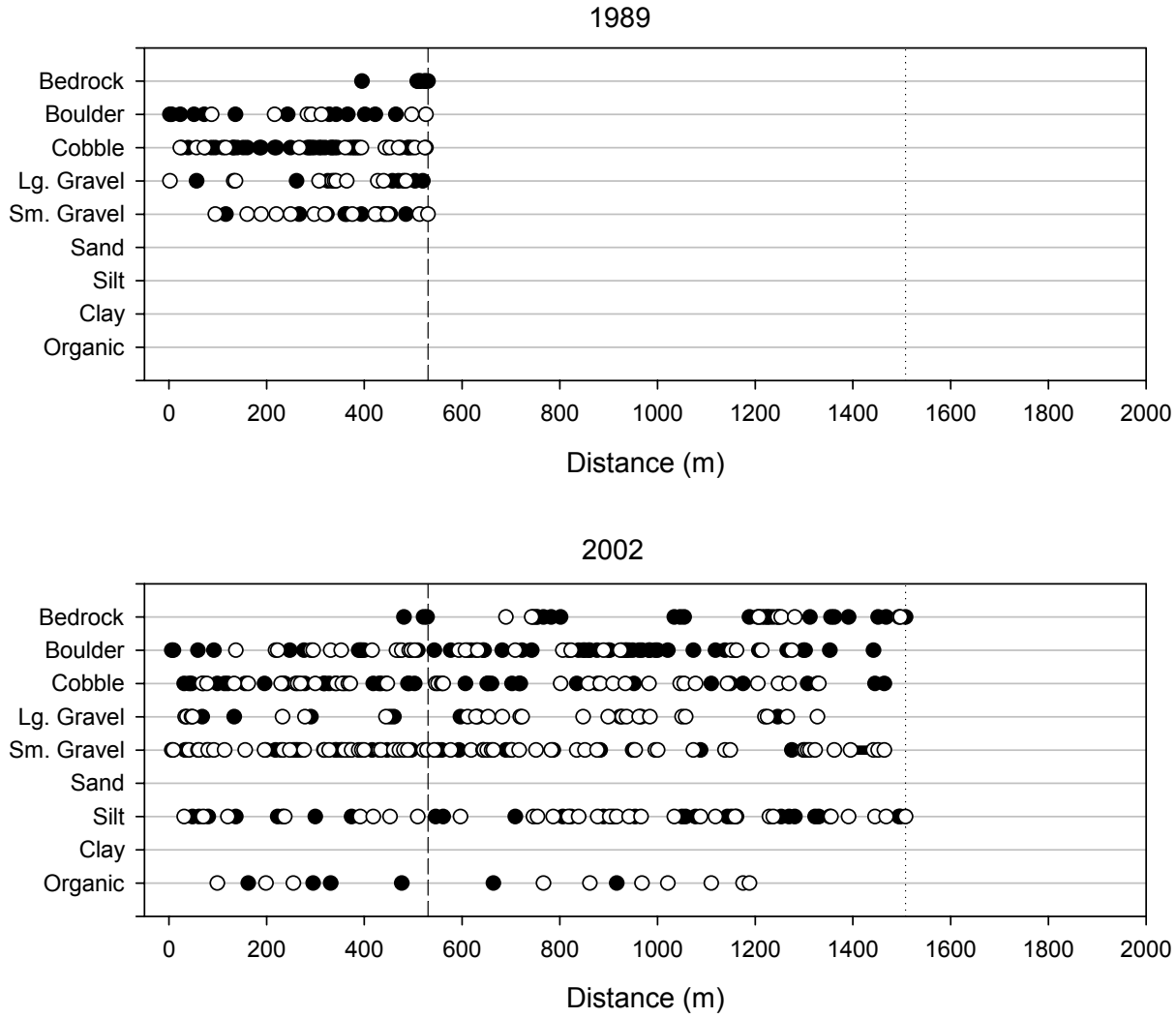

Figure A20. Distribution of substrate types (Table 2) in Chimney Branch, 1989 and 2002. Closed circles are dominant substrates, open circles are subdominant substrates. Distance is meters upstream of confluence with St. Mary's River. Vertical dashed line indicates end of 1989 BVET habitat survey. Vertical dotted line indicates end of 2002 BVET habitat survey.

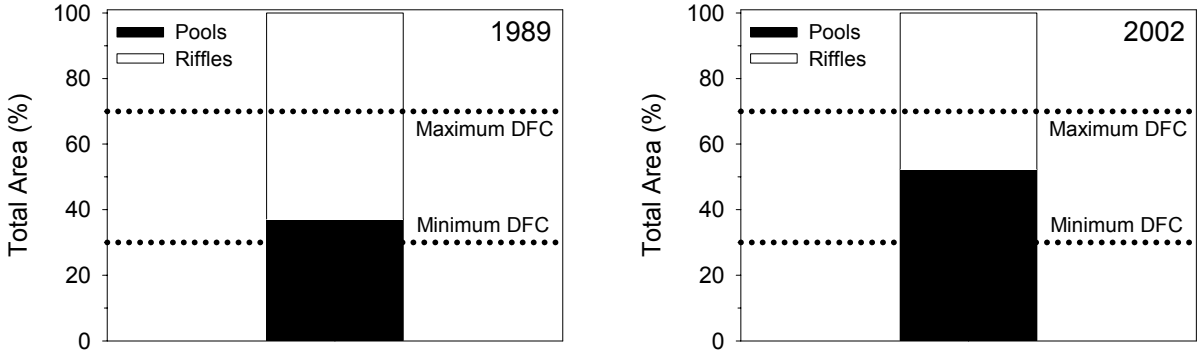

Figure A21. Estimated area of Chimney Branch pools and riffles as calculated using BVET techniques, 1989. The GWJNF DFC is between 30 and 70 percent of total stream area in pools.

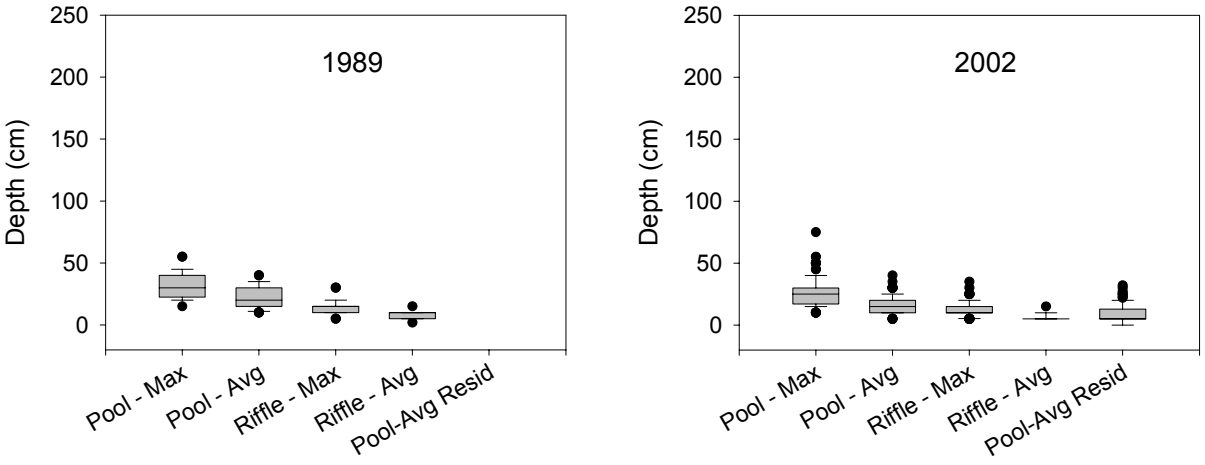

Figure A22. Maximum and average depths for pools and riffles in Chimney Branch, 1989 and 2002. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of the box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data. Residual depths were not calculated 1989.

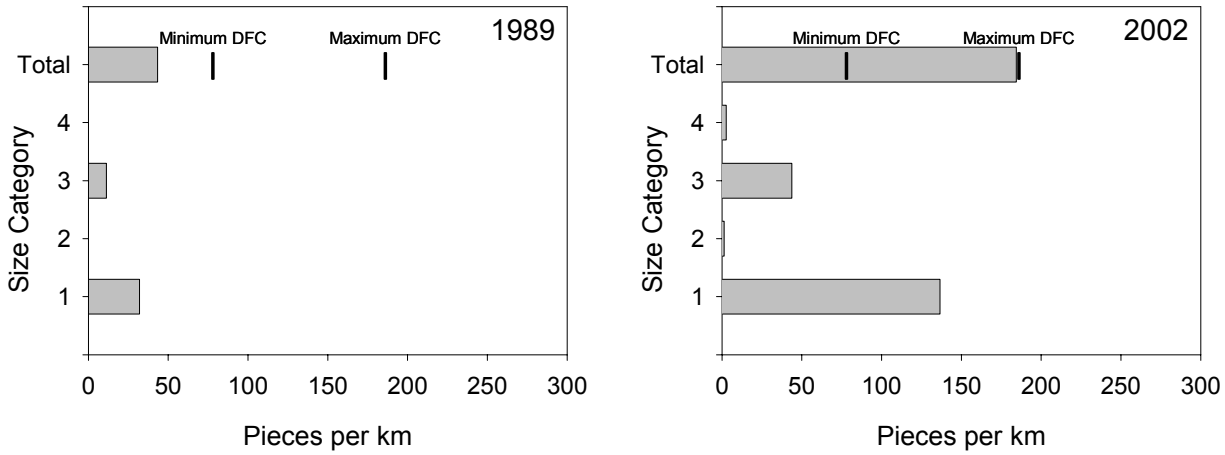

Figure A23. LWD per kilometer in Chimney Branch, 1989 and 2002. The GWJNF DFC for total LWD is between 78 and 186 pieces per km.

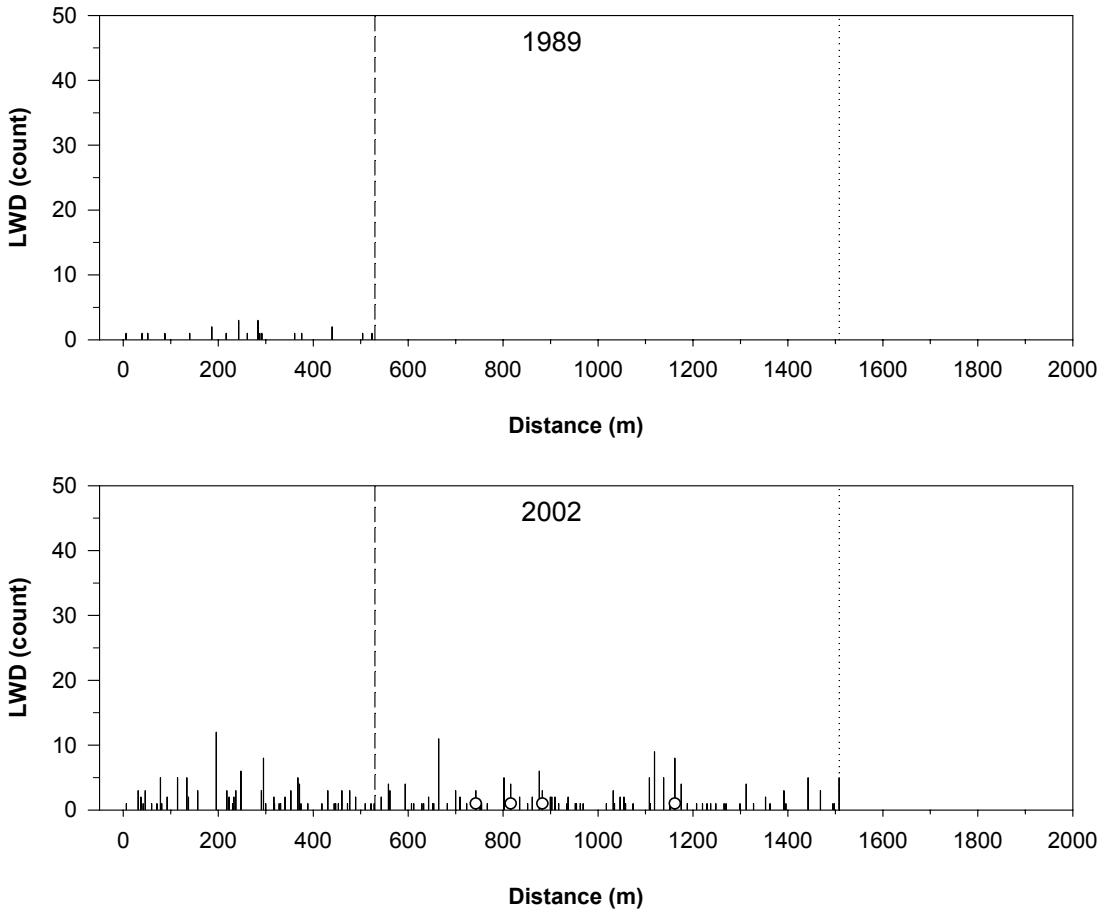

Figure A24. Distribution and abundance of LWD in Chimney Branch, 1989 and 2002. Vertical bars indicate total count of LWD. Open circles represent the amount of the total that was >5m in length and >55cm in diameter (size 4). Distance is meters upstream of confluence with St. Mary's River. Vertical dashed line indicates end of 1989 BVET habitat survey. Vertical dotted line indicates end of 2002 BVET habitat survey.

Table A7. Summary of habitat characteristics for St. Mary's River entire ms , 2002.

Stream:	**St. Mary's River/entire ms**
NF District:	Pedlar
USGS Quadrangle:	big levels
Survey Date:	07/29/02
Downstream Starting Point:	wilderness boundary
Total Distance Surveyed (km):	7.7

	Pools	**Riffles**
Percent of Total Stream Area:	49	51
Total Area (m^2):	17979 ± 674	18495 ± 3683
Correction Factor Applied:	0.92	1.03
Number of Paired Samples:	11	13
Total Count:	298	271
Number per km:	39	35
Mean Area (m^2):	60	68
Mean Maximum Depth (cm):	51	23
Mean Average Depth (cm):	29	13
Mean Residual Depth (cm):	16	--
Percent Surveyed as Glides:	13	--
Percent Surveyed as Runs:	--	13
Percent Surveyed as Cascades:	--	0
Percent with Substrate > 35% Embedded:	5	--

Large Woody Debris Size	Pieces per km
< 5 m long, 10 cm – 55 cm diameter:	47
< 5 m long, > 55 cm diameter:	0
> 5 m long, 10 cm – 55 cm diameter:	7
> 5 m long, > 55 cm diameter:	0
Total:	54

Rosgen's Channel Type	**Frequency (%)**
A:	0
B:	100
C:	0
D:	0
E:	0
F:	0
G:	0

Other Stream Attributes	
Mean Channel Gradient (%):	4
Median Water Temperature (C):	22

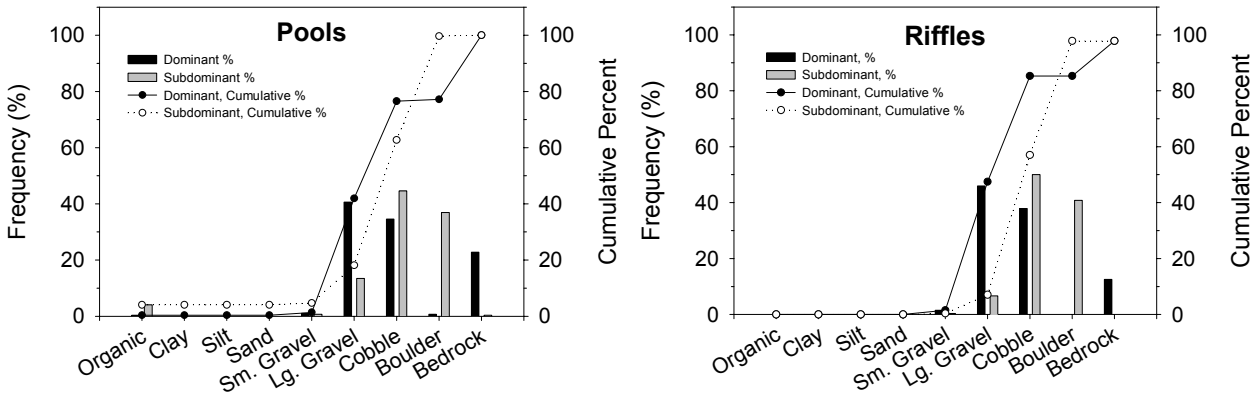

Figure A25. Frequency (percent) and cumulative percent of dominant and subdominant substrate occurrence in pools and riffles in St. Mary's River entire ms, 2002.

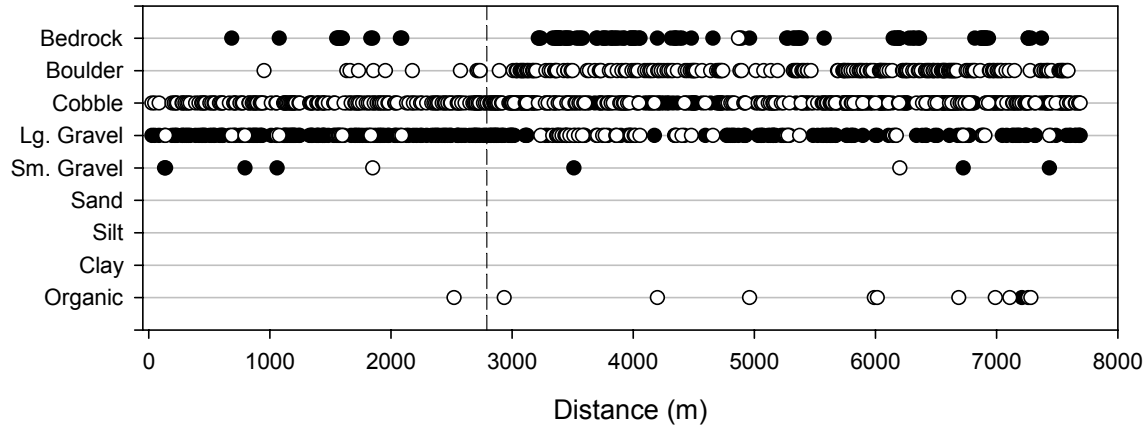

Figure A26. Distribution of substrate types (Table 2) in St. Mary's River entire ms, 2002. Closed circles are dominant substrates, open circles are subdominant substrates. Distance is meters upstream of wilderness boundary. Vertical dashed line indicates confluence with Sugartree branch.

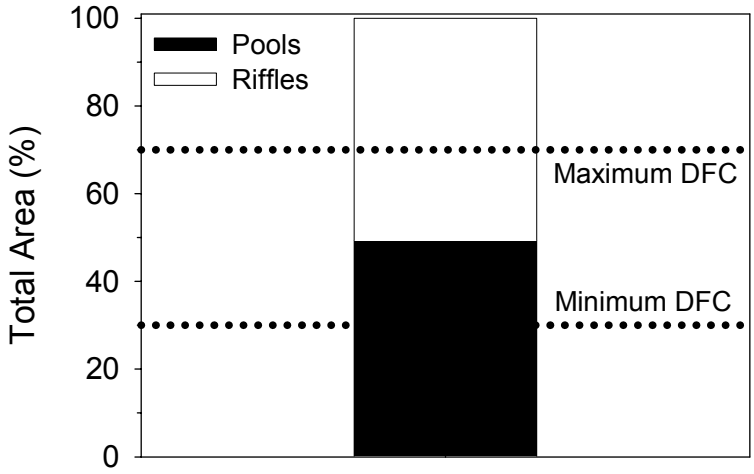

Figure A27. Estimated area of St. Mary's River entire ms pools and riffles as calculated using BVET techniques, 1989. The GWJNF DFC is between 30 and 70 percent of total stream area in pools.

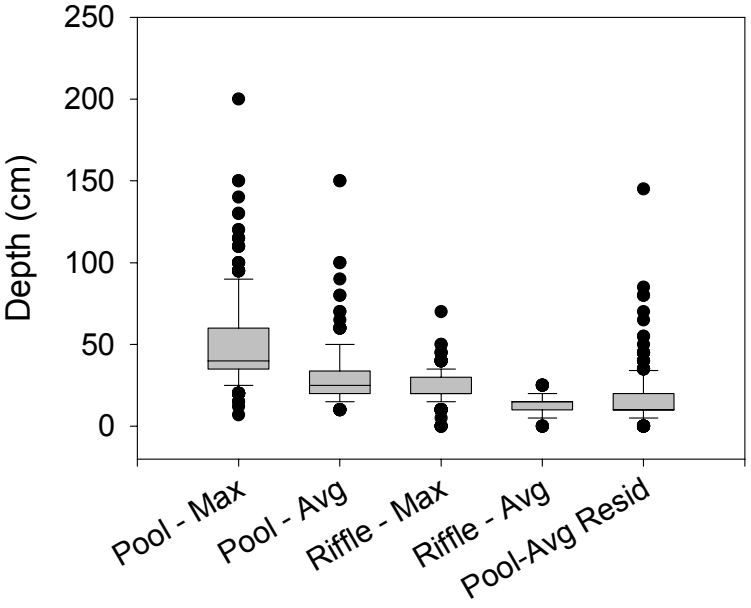

Figure A28. Maximum and average depths for pools and riffles and residual pool depths in St. Mary's River entire ms, 2002. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of the box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

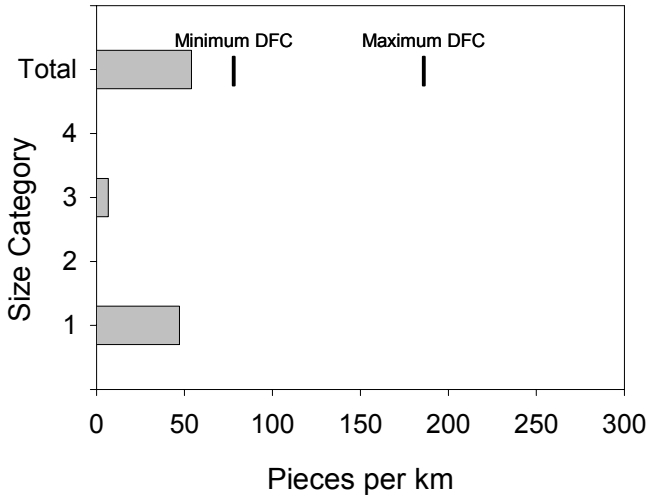

Figure A29. LWD per kilometer in St. Mary's River entire ms, 2002. The GWJNF DFC for total LWD is between 78 and 186 pieces per km.

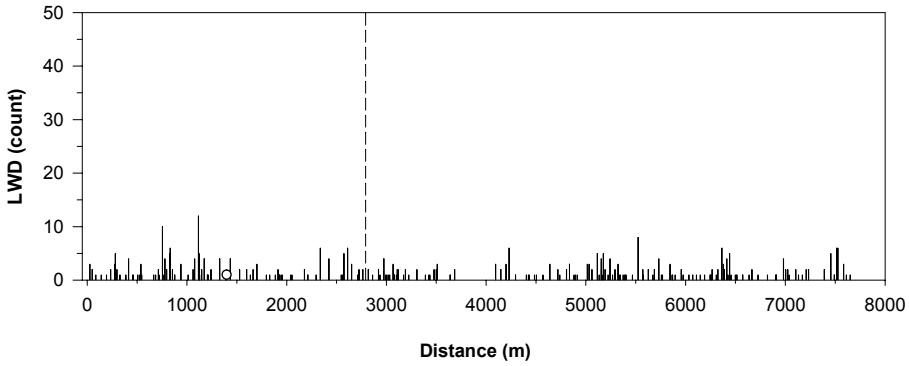

Figure A30. Distribution and abundance of LWD in St. Mary's River entire ms, 2002. Vertical bars indicate total count of LWD. Open circles represent the amount of the total that was >5m in length and >55cm in diameter (size 4). Distance is meters upstream of confluence with St. Mary's River. Vertical dashed line indicates confluence with Sugartree Branch.

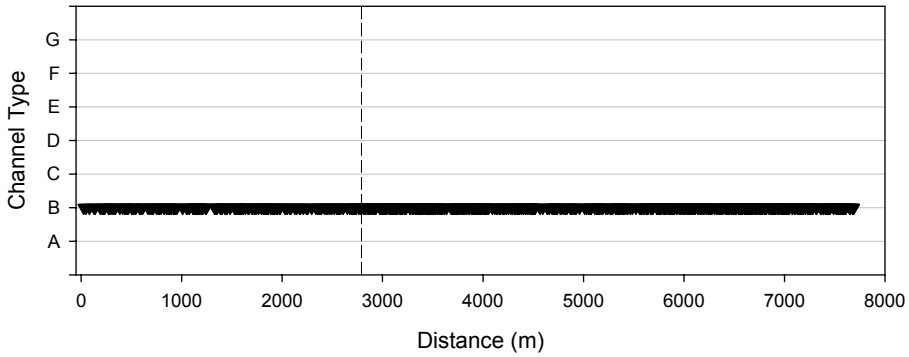

Figure A31. Rosgen channel type for St. Mary's River entire ms, 2002. Distance is meters upstream of wilderness boundary. Vertical dashed line indicates confluence with Sugartree Branch.

Table A8. Summary of habitat characteristics for Sugartree Branch, 2002.

Stream:	**Sugartree Branch**
NF District:	Pedlar
USGS Quadrangle:	big levels
Survey Date:	07/29/02
Downstream Starting Point:	confluence with St. Mary's River
Total Distance Surveyed (km):	1.6

	Pools	**Riffles**
Percent of Total Stream Area:	48	52
Total Area (m^2):	1493 ± 89	1632 ± 27
Correction Factor Applied:	0.90	0.83
Number of Paired Samples:	17	12
Total Count:	106	77
Number per km:	67	49
Mean Area (m^2):	14	21
Mean Maximum Depth (cm):	33	18
Mean Average Depth (cm):	20	9
Mean Residual Depth (cm):	15	--
Percent Surveyed as Glides:	12	--
Percent Surveyed as Runs:	--	18
Percent Surveyed as Cascades:	--	4
Percent with Substrate > 35% Embedded:	6	--

Large Woody Debris Size	Pieces per km
< 5 m long, 10 cm – 55 cm diameter:	112
< 5 m long, > 55 cm diameter:	1
> 5 m long, 10 cm – 55 cm diameter:	42
> 5 m long, > 55 cm diameter:	3
Total:	157

Other Stream Attributes	
Mean Channel Gradient (%):	10
Median Water Temperature (C):	19.5

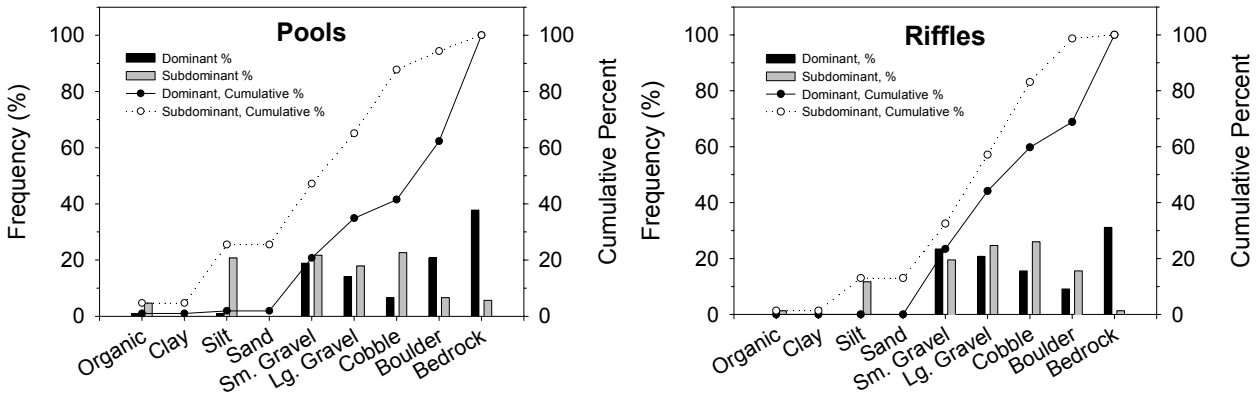

Figure A32. Frequency (percent) and cumulative percent of dominant and subdominant substrate occurrence in pools and riffles in Sugartree Branch, 2002.

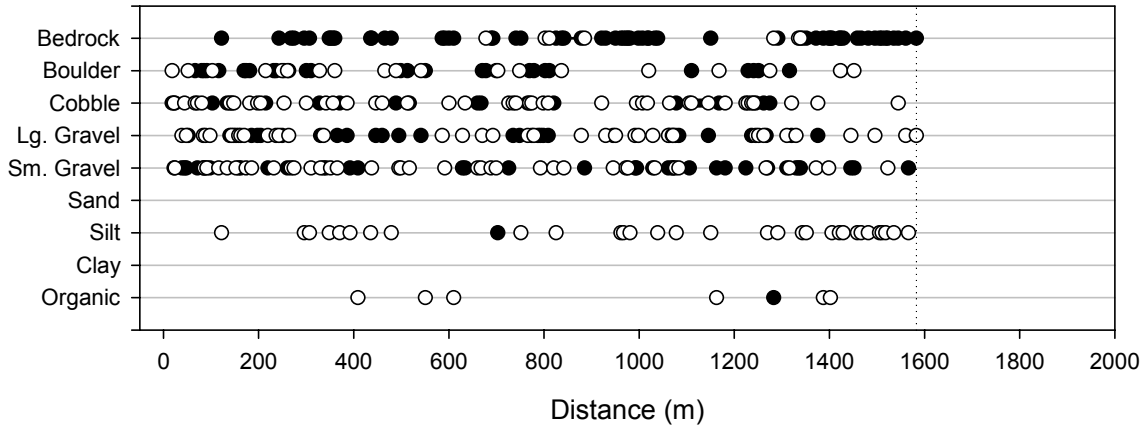

Figure A33. Distribution of substrate types (Table 2) in Sugartree Branch, 2002. Closed circles are dominant substrates, open circles are subdominant substrates. Distance is meters upstream of confluence with St. Mary's River. Vertical dotted line indicates ending point of 2002 BVET habitat survey.

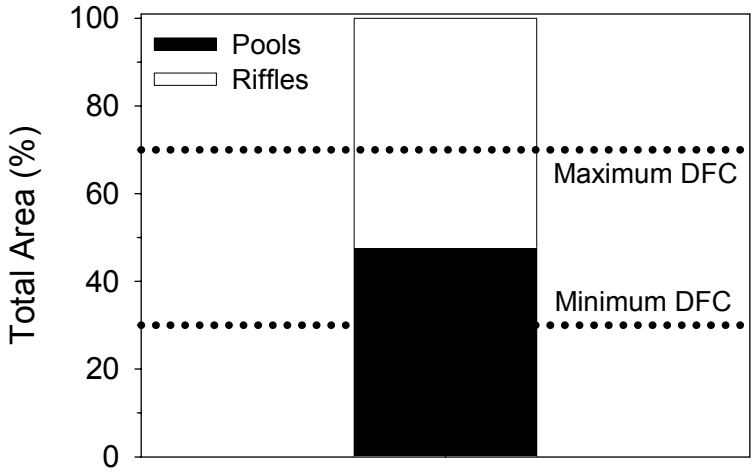

Figure A34. Estimated area of Sugartree Branch pools and riffles as calculated using BVET techniques, 2002. The GWJNF DFC is between 30 and 70 percent of total stream area in pools.

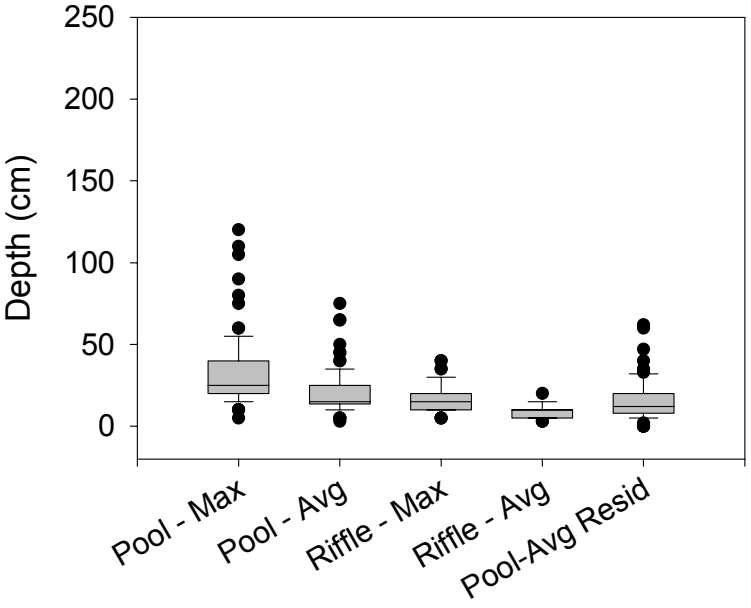

Figure A35. Maximum and average depths for pools and riffles and residual pool depths in Sugartree Branch, 2002. The top and bottom of the boxes represent the 25th and 75th percentiles, the bar in the center of the box represents the median, whiskers represent the 10th and 90th percentiles, and closed circles represent the entire range of the data.

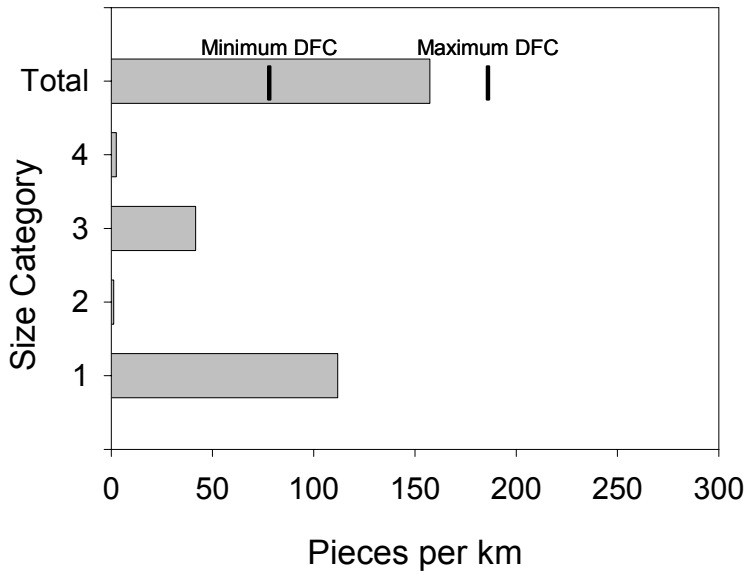

Figure A36. LWD per kilometer in Sugartree Branch, 2002. The GWJNF DFC for total LWD is between 78 and 186 pieces per km.

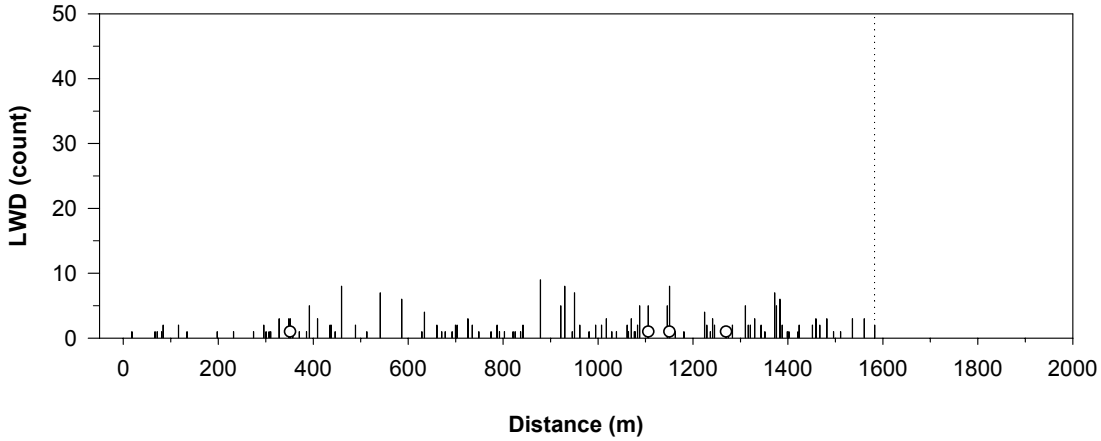

Figure A37. Distribution and abundance of LWD in Sugartree Branch, 2002. Vertical bars indicate total count of LWD. Open circles represent the amount of the total that was >5m in length and >55cm in diameter (size 4). Distance is meters upstream of confluence with St. Mary's River. Vertical dotted line indicates ending point of 2002 BVET habitat survey.

Appendix B: Fish Survey Summaries

Table B1. Species observed during surveys in St. Mary's River mainstem by year.

common name	**scientific name**	**1989**	**1994**	**1997**	**1999**	**2002**
brook trout	*Salvelinus fontinalis*	X	X	X	X	X
rainbow trout	*Oncorhynchus mykiss*	X				
blacknose dace	*Rhinichthys atratulus*	X	X	X	X	X
mottled sculpin	*Cottus bairdi*	X	X		X	X
fantail darter	*Etheostoma flabellare*	X	X	X	X	X
central stoneroller	*Campostoma anomalum*	X				X
roseyside dace	*Clinostomus funduloides*				X	X
torrent sucker	*Thoburnia rhothoeca*					X

Table B2. Brook trout density estimates (adult and YOY combined) with 95% confidence intervals (CI) in St. Mary's River.

date	reach	density (fish/100m^2)	95% CI + or -
1989	upper ms	5	5
	entire ms	--	--
1994	upper ms	6	2
	entire ms	--	--
1997	upper ms	16	7
	entire ms	19	5
1999	upper ms	--	--
	entire ms	12	6
2002	upper ms	23	8
	entire ms	20	7

Table B3. Blacknose dace density estimates with 95% confidence intervals (CI) in St. Mary's River.

date	reach	density (fish/100m^2)	95% CI + or -
1989	upper ms	0.4	0.7
	entire ms	--	--
1994	upper ms	1.2	0.1
	entire ms	--	--
1997	upper ms	--	--
	entire ms	--	--
1999	upper ms	--	--
	entire ms	4.3	1.0
2002	upper ms	5.4	1.7
	entire ms	7.3	7.1

Table B4. Adult brook trout density estimates with 95% confidence intervals (CI) in pools, riffles and total stream (pools and riffles combined) in St. Mary's River, 1989, 1994, 1997, 1999, and 2002.

		adults in pools		adults in riffles		adults in total stream	
date	**reach**	**density (fish/100m^2)**	**95% CI + or -**	**density (fish/100m^2)**	**95% CI + or -**	**density (fish/100m^2)**	**95% CI + or -**
1989	upper ms	5	4	2	5	4	4
	entire ms	--	--	--	--	--	--
1994	upper ms	1	0.5	0.4	0.4	1	0.4
	entire ms	--	--	--	--	--	--
1997	upper ms	2	1	0	1	1	1
	entire ms	3	1	0.3	0.3	2	1
1999	upper ms	4	2	--	--	--	--
	entire ms	7	4	1	1	4	3
2002	upper ms	22	3	7	4	15	3
	entire ms	22	5	5	3	13	4

Table B5. YOY brook trout density estimates with 95% confidence intervals (CI) in pools, riffles, and total stream (pools and riffles combined) of the St. Mary's River, 1989, 1994, 1997, and 2002.

		YOY in pools		YOY in riffles		YOY in total stream	
date	**reach**	**density (fish/100m^2)**	**95% CI + or -**	**density (fish/100m^2)**	**95% CI + or -**	**density (fish/100m^2)**	**95% CI + or -**
1989	upper ms	1	1	1	1	1	1
	entire ms	--	--	--	--	--	--
1994	upper ms	7	1	3	1	5	1
	entire ms	--	--	--	--	--	--
1997	upper ms	19	6	9	7	15	6
	entire ms	19	4	16	5	17	4
1999	upper ms	10	6	2	1	6	4
	entire ms	12	5	3	2	8	3
2002	upper ms	6	2	8	9	7	5
	entire ms	6	2	7	5	7	3

Table B6. Brook trout density estimates (adults and YOY combined) with 95% confidence intervals (CI) in total stream (pools and riffles combined) for all tributaries combined, 1994, 1997, 1999, and 2002.

date	density (fish/100m^2)	95% CI + or -
1994	5	5
1997	5	8
1999	5	6
2002	10	7

Table B7. Adult brook trout density estimates with 95% confidence intervals (CI) in pools and total stream (pools and riffle combined) for all tributaries combined.

	adults in pools		adults in total stream	
date	density (fish/100m^2)	95% CI + or -	density (fish/100m^2)	95% CI + or –
1994	2	2	1	1
1997	2	3	1	1
1999	7	10	3	4
2002	18	9	8	4

Table B8. YOY brook trout density estimates with 95% confidence intervals (CI) in pools, riffles, and total stream (pools and riffle combined) for all tributaries combined.

	YOY in pools		YOY in riffles		YOY in total stream	
date	density fish/100m^2	95% CI + or -	density fish/100m^2	95% CI + or -	density fish/100m^2	95% CI + or -
1989	--	--	--	--	--	--
1994	8	7	2	3	4	5
1997	10	14	--	--	4	6
1999	4	3	--	--	2	1
2002	5	8	--	--	2	3

Table B9. Furthest upstream observation of species in St. Mary's River, 1989, 1997, 1999, and 2002. Distance is meters upstream of the wilderness boundary adjacent to the trailhead parking area at the end of Forest Service Road 41.

species	1989 distance (m)	1997 distance (m)	1999 distance (m)	2002 distance (m)
brook trout	7635.8	7023.0	6954.1	7588.0
rainbow trout	4973.0	--	--	--
blacknose dace	3629.1	149.7	2858.9	5736.4
mottled sculpin	3195.3	--	243.6	3296.5
fantail darter	3629.1	1921.2	2858.9	3526.5
central stoneroller	2616.7	--	--	926.5
roseyside dace	--	--	709.1	445.8
torrent sucker	2616.7	--	--	2353.8

Table B10. Furthest upstream observation of brook trout in selected tributaries of the St. Mary's River, 1997, 1999, and 2002. Distance is meters upstream from the confluence with St. Mary's River.

stream	1997 distance (m)	1999 distance (m)	2002 distance (m)
Sugartree Branch	572.7	447.2	1544.7
Mine Bank Creek	463.1	511.5	1538.6
Hogback Creek	180.0	280.0	388.8
Chimney Branch	537.5	493.4	942.0

Table B11. Furthest upstream observation of mottled sculpin in Sugartree Branch, 1997, 1999, and 2002. Distance is meters upstream from the confluence with St. Mary's River.

stream	1997 distance (m)	1999 distance (m)	2002 distance (m)
Sugartree Branch	203.6	169.8	300.3